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Contents :

THE PRINCIPAL OFFICERS, 1950/51

MODERN FOUNDRY PRACTICE
By C. S. Johnson, B.Sc., A.I.M.

HISTORY AND DEVELOPMENT
OF THE INSTITUTION'S RESEARCH ACTIVITIES

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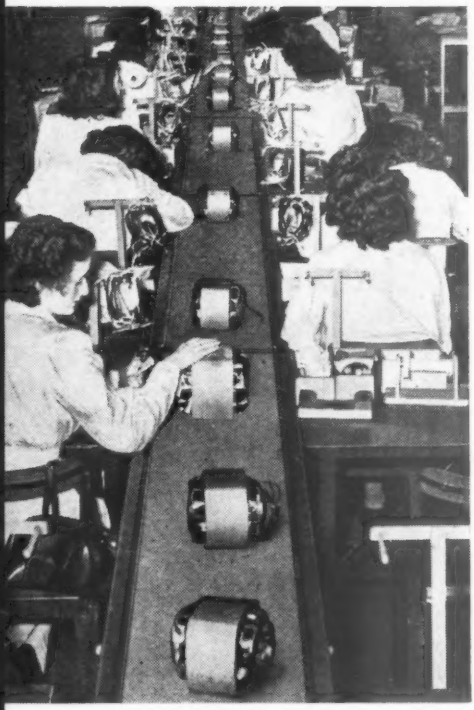

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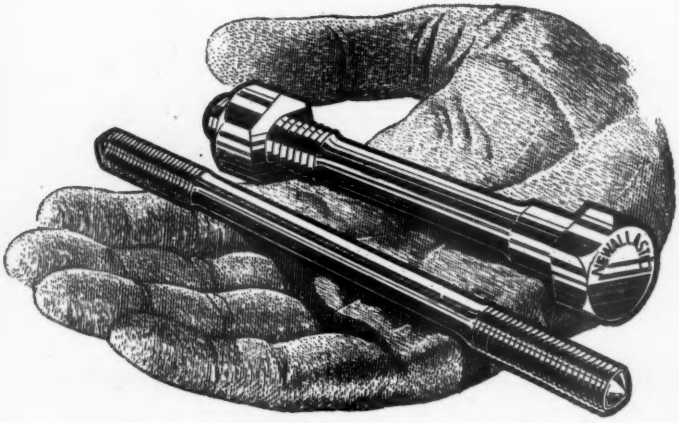

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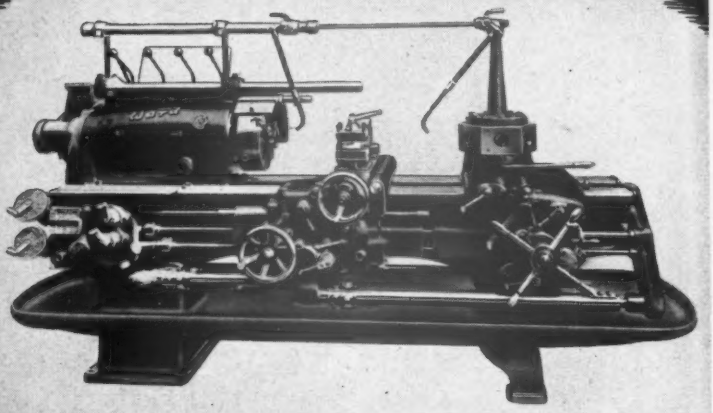

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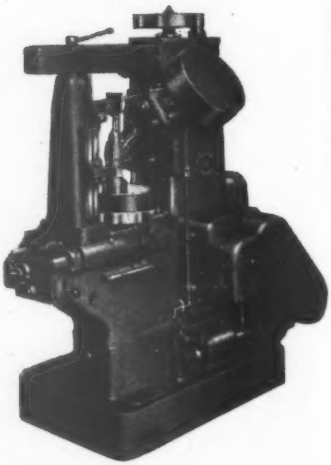

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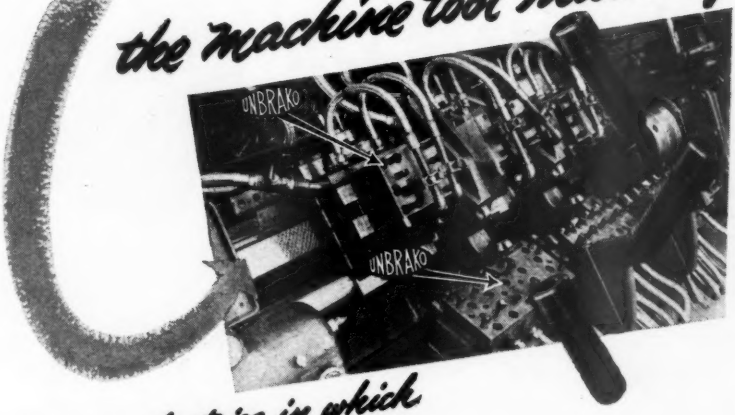

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Some facts about zinc alloy die casting

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STRENGTH: Good mechanical properties for stressed components.

ACCURACY: Castings can be made practically to finished dimensions and need little or no machining.

STABILITY: Close tolerances are maintained throughout the life of the casting.

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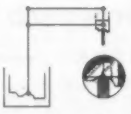
Forms are produced from a pencil and paper layout 50 times the size of the profile required. The work is focussed under the microscope and the tracing point of the pantograph moved step by step along the drawn profile. At each step the reciprocating grinding wheel is fed manually into the work, and the exact progress of grinding can be followed in the field of the projection screen or microscope.

A form up to 5¼" in length and 2½" in depth in a workpiece 2" thick can be ground. Circular form tools are produced on a separate circular grinding attachment.

The combined microscope and projection screen is seen in the above close-up of the upper head on which can be noted a vernier for setting the wheel to grind an angle, producing clearances, etc., with a maintained form.



The pantograph imparts a 50:1 reduction from the pencil layout to its final arm, in which is incorporated the combined microscope and projection screen.

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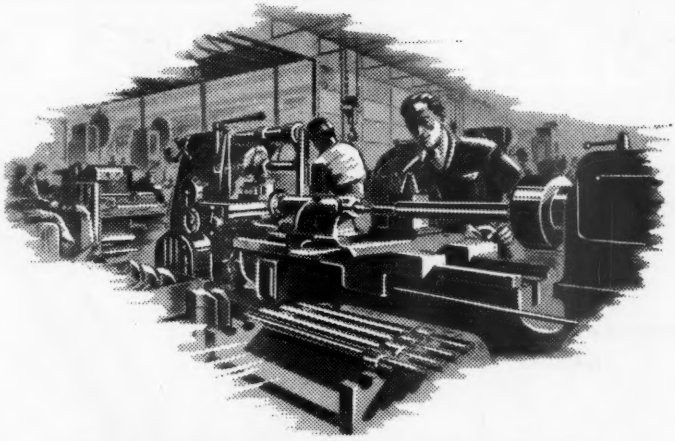

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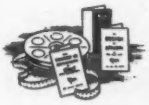

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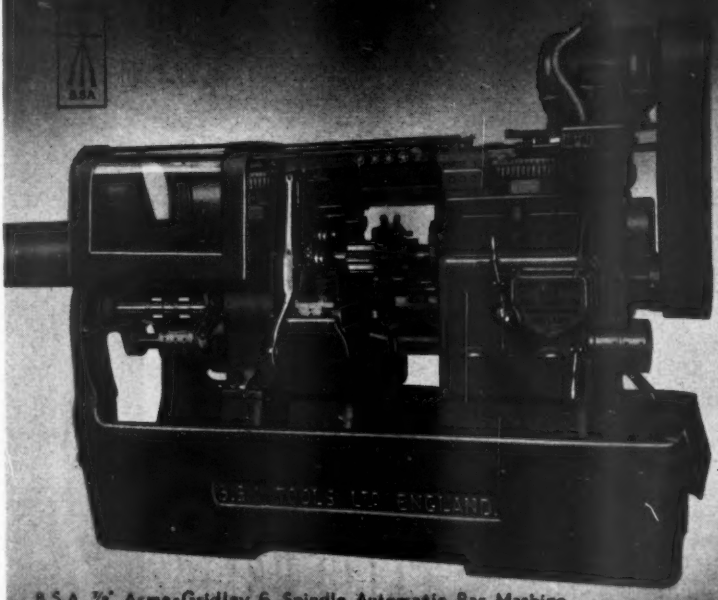

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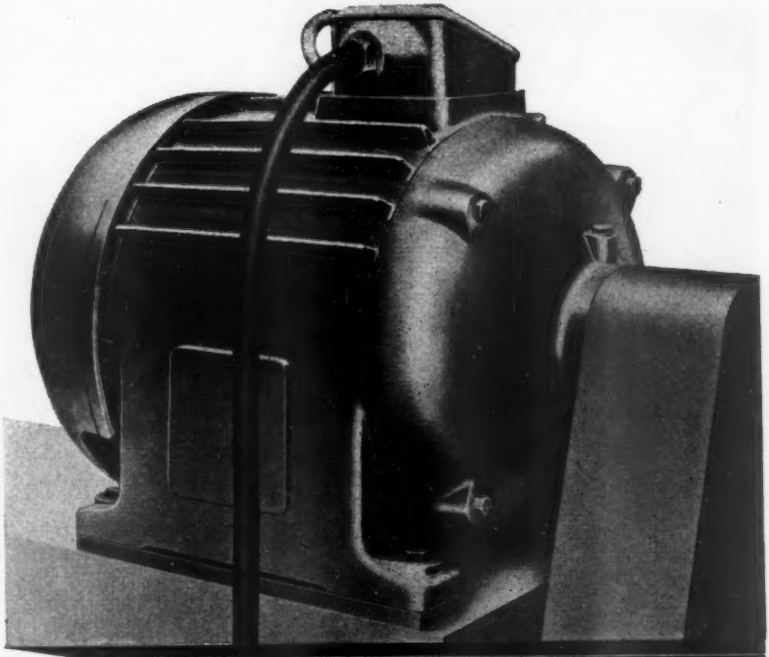

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THE PRINCIPAL OFFICERS, 1950/51

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General Appleyard is not only an eminent industrialist and a highly qualified engineer, who is known for his achievements both in this country and abroad, but he has also had a distinguished military career in two World Wars.

In addition to the professional institutions indicated above, he is a member of the North East Coast Institution of Engineers and Shipbuilders, and the Iron and Steel Institute, and is a Past President of the Junior Institution of Engineers. In 1946, he was awarded a Telford Premium by the Institution of Civil Engineers.

MAJ.-GEN. K. C. APPLEYARD

He is also a recognised authority on all aspects of labour relations.

In June, 1940, General Appleyard was loaned to the Government by the Army to become Director of Labour Supply and Adviser to the Ministry of Labour and National Service. This was followed by a succession of appointments calling for the highest skill and administrative ability as Director of the International Labour Branch; Director of Emergency Works in the Ministry of Works; Director of Opencast Coal Production; and Adviser to the Minister of Works on Regional Organisation.

As a member of the Durham County Council and Chairman of its Works Committee, the President has had considerable experience of Local Government. He is a Deputy Lieutenant and Justice of the Peace for the County of Durham, Vice-President of Durham Municipal and County Federation, and Member of Council of the North East Coast Development Board.

The Institution of Production Engineers is indeed fortunate to have as its President a man of such exceptional talent and ability.

The Chairman of Council

Mr. Walter C. Puckey, M.I.Prod.E., F.I.I.A.

Mr. Puckey, Director and General Works Manager of Hoover, Ltd., is well-known to members for his valuable service and progressive leadership in Institution activities, and has achieved distinction in many spheres as a draughtsman, engineer, teacher, lecturer, and author.

In 1937 he was presented by Lord Nuffield with the Institution Medal for a paper entitled "Personal Problems of Management," and in 1944 his book, "What Is This Management?" was published. The Right Hon. Oliver Lyttelton, in a foreword, described this book as "a contribution from an experienced and successful manager to our studies in the art and science of this vital subject."

MR. WALTER C. PUCKEY

At the age of 32, Mr. Puckey was Works Manager of a motor manufacturing company, and was invited to become Works Manager of Hoover, Limited, in July, 1935. He became a Director in April, 1944.

During the war he was in close contact with various Ministries. He was a pioneer member of the Production Advisory Committee on Diecasting, initiated by the Ministry of Supply, and served on the Industrial Panel of the Minister of Production. He also sat as an independent member on the Hosiery Working Party appointed by Sir Stafford Cripps. He has recently been appointed to the Dollar Exports Board.

Mr. Puckey has served as Chairman of a number of Institution committees, and he was responsible for the formation of the Technical and Publications Committee. He is a tireless traveller, and has become known to members by his many personal visits to local Sections.

HISTORY and DEVELOPMENT of the INSTITUTION'S RESEARCH ACTIVITIES

INTRODUCTION

The Institution has always been aware that the maintenance of the highest standards of Production Engineering technique and the constant development of new processes cannot take place without the aid of research. During its early years, neither resources nor manpower were available for this purpose, but as long ago as 1932 the Examinations and Research Committee were exploring the possibility of getting Technical Colleges to arrange for their students to carry out research work under the control of the Principal of the College and the general guidance of the Council of the Institution. This scheme does not seem to have met with much success, but it paved the way for future developments.

In January 1936 the late Dr. Georg Schlesinger, an outstanding international authority on Machine Tool research, who was then working in Brussels, was invited to give a lecture to the Institution on " Machine Tool Tests and Alignments." The late General Secretary, Mr. Richard Hazleton, on learning that Dr. Schlesinger wished to settle in this country, discussed with Dr. Schofield the possibility of establishing a Production Engineering Research Centre at Loughborough College, which was by far the most advanced centre for production engineering training and possessed well-equipped workshops and laboratories. Having obtained Dr. Schofield's support, Mr. Hazleton and other leading members of the Institution successfully conducted the negotiations which led to the appointment of Dr. Schlesinger as Director of the new Research Centre in 1938. These events took place whilst Lord Nuffield was President of the Institution, and when it became clear that the Institution could not afford to pay Dr. Schlesinger a salary commensurate with his duties and qualifications, Lord Nuffield, with characteristic generosity, presented the Institution with a capital sum of £25,000.

ESTABLISHMENT OF THE RESEARCH DEPARTMENT

Arrangements were made for the Research Department to be accommodated at Loughborough College, through the generosity of its governing body ; funds were provided partly by a direct contribution from the I.Prod.E. but largely by regular annual donations

from affiliated firms. Under the guidance of Dr. Schlesinger, the Research Department carried out work on the machinability of materials, cutting tools, and other special technical aspects of production engineering. Its two principal achievements were, however, the Report on Surface Finish, published by the Institution in 1939, and the preparation of a series of Test Charts for Machine Tools, published jointly by the I.Prod.E. and the Institution of Mechanical Engineers. The research policy and programme of the Department was formulated by a standing Research Committee set up in 1939, consisting of ten members of the Institution and representatives of the Institution of Mechanical Engineers, the Department of Scientific and Industrial Research, Loughborough College and the Machine Tool Trades Association, under the Chairmanship of Mr. J. H. Bingham. A Research Department Committee was also set up to handle the detailed supervision of research work, under the Chairmanship of Mr. Mark H. Taylor. At the same time it was decided to invite the co-operation of the Institution of Mechanical Engineers in the choice of a research programme, and a Standing Joint Committee on Research was set up in 1939. The Research Staff was strengthened by the appointment of Dr. D. F. Galloway, B.Sc., Wh.Sch., M.I.Mech.E., M.I.Prod.E., A.M.I.E.E., as Assistant Director in 1939. Dr. Galloway was subsequently appointed Director of Research when Dr. Schlesinger retired in 1944.

To cover the vast amount of work undertaken by the Research Department would take too much space in this brief review of our research activities. Several important pieces of research were undertaken on behalf of the Ministry of Supply during the war, and work expanded rapidly until in 1942 it was thought desirable to make a formal approach to the Department of Scientific and Industrial Research for a grant in aid. However, the attitude of D.S.I.R. was that such a grant could not be made to a research body so closely linked to a professional institution and to an educational establishment like Loughborough College ; the granting of government support to regularly constituted Research Associations rested on the principle that funds must be provided by the industry to benefit by the research. The Institution's application was made on the ground that Production Engineering Research, being concerned with productive methods and not with products, would be of great value to a wide range of industries rather than to any particular industry.

It was clear that if the work of the Research Department was to continue to develop and to assist industry on a national scale, adequate resources could only be provided by the creation of a separate national research organisation which could qualify for support from D.S.I.R. Such a body would, in fact, derive its

income from the industrial interests benefiting from the research, and would receive a pound-for-pound grant from D.S.I.R. when its funds had reached a certain minimum level. Therefore, although the Institution was not anxious to hand over its responsibility for production engineering research, it was recognised that to do so would in fact be in the best interests of the engineering industry, and hence, although indirectly, in the best interests of Production Engineering.

FORMATION OF THE PRODUCTION ENGINEERING RESEARCH ASSOCIATION

The Institution therefore entered into negotiations with the Machine Tool Trades Association, the Gauge and Tool Makers' Association and the National Federation of Engineers' Tool Manufacturers, as important representatives of engineering production in Great Britain, and these four organisations undertook to provide jointly the necessary financial backing to launch a separate national research organisation. By 1944 a Shadow Council for the Production Engineering Research Association of Great Britain had been constituted, on which all four bodies were represented, and in the following year negotiations with the Department of Scientific and Industrial Research had been successfully concluded.

The Production Engineering Research Association entered the first year of its legal existence in July, 1946. Accommodation was found at a large country house in Melton Mowbray with outbuildings which could be converted into laboratories, and the new organisation, under the guidance of its Director, Dr. Galloway, faced the major tasks of building up its membership and preparing the way for a fresh programme of research. P.E.R.A. has now successfully surmounted all its early difficulties, and has achieved a secure position with a strong membership.

OPERATIONAL RESEARCH

THE NEW RESEARCH POLICY

Although the Institution no longer has a direct responsibility for promoting research to improve the actual tools of production, Council are well aware that there are many other aspects of production engineering technique which are susceptible of improvement through research. For instance, it is obvious that great improvements in efficiency could result from attempts to reduce non-productive time, both by better machine utilisation and by the use of mechanical aids for handling materials, but research is necessary to estimate the hoped-for increase in exact percentage terms. The whole field of "productivity" includes so much unexplored territory that many decisions of management designed to increase production still have to be made on a basis of guesswork rather than of fact.

It was in the hope that the Institution might be able to play a significant part in charting some of these unknown territories that Council in 1948 directed the Institution's research policy into the new channel of operational research. In July 1948 the Research Committee was reconstituted for this task.

WHAT IS OPERATIONAL RESEARCH ? The term " operational research " is a product of the second World War. Literature on the subject is widely scattered amongst technical and scientific journals, so it may be useful to define it and describe its technique, and then to give some examples of its application, so that the Institution's research policy can be seen in relation to the general background. It will then be shown how operational research can be applied in the industrial field, and particularly within the sphere of production engineering.

(*a*) *Definition.* Operational Research has been defined by some of its leading exponents as " the use of scientific method to provide executives with an analytical and objective basis for decisions." In its fully developed form it requires teams of trained scientists and statisticians, who work in close collaboration with the executives they serve, but the definition is a wide one, and some of the work now being done by industrial Research Associations and by individual companies can well be described as operational research, although the technique may not be developed to such a high degree. It involves examination of every relevant aspect of a given problem, in the light of commonsense supported by statistics.

(*b*) *Operational Research as distinct from Product Research.* The main activities of industrial research bodies in the past have been directed to the improvement and development of the products of the industry concerned. Within individual companies, research has frequently been the concern of the design department only, and resulted in a series of modifications of the product. But in order to make the same product at a more economic cost, there must first be an investigation into all the factors affecting its production, by means of such techniques as quality control, cost control, machine utilisation, stock control and time and motion study ; when all this data is presented to management in a tabular or graphical form, the decision to make any change in the organisation of production can be based on sound factual information. In this case, the management have put in hand a simple piece of operational research, which illustrates Sir Edward Appleton's definition of operational research as " the arithmetic of what happens when we make a change—and when we don't."

(*c*) *Some Characteristics of Operational Research.* The characteristics of Operational Research in the strict sense will be illustrated by the

examples which are given below, but they can be summarised briefly as follows :—

(i) It applies research methods to the study of problems.

(ii) The research team may include specialists in any appropriate branches of science or technology, but they must possess knowledge of the proper statistical techniques and be able to take a very broad view of the problems.

(iii) The team must work in the closest contact with the executives they serve, in order to have full access to all data and gain a clear picture of all practical considerations affecting any changes they may recommend.

(*d*) *Techniques.* Operational research employs a number of well-known statistical devices such as sampling and variational method. Most problems have many variable factors which appear to vary in uncoordinated ways. In addition, there may be superimposed on these a number of chance fluctuations which tend to mask the true correlations. The problem can be tackled by an analysis of past experience, to determine the intensity of correlation between any pair of variables. If such a correlation is found, then the next step is to find its form (i.e., the " regression " of one on the other). Finally, it is necessary to discover the causes of the regression, and when these have been established, it will be possible to predict a future situation with some confidence.

The following wartime example illustrates this technique :

An investigation was made to discover whether the number of ships sunk in a convoy depended on the speed of the convoy. Here the rates of sinking were correlated to changes of speed, and it was established that higher rates of sinking did occur more frequently with slow convoys, other factors such as the size of convoy, air and sea protection, etc., being constant. Such a correlation would not in itself indicate a relation of cause and effect, but a direct causal link between the two variable factors was deduced from a study of enemy submarine tactics. It could, therefore, safely be predicted that if a certain increase was made in the speed of convoys, a certain increased safety was to be expected.

OPERATIONAL RESEARCH IN PRACTICE

(*a*) *During the war.* These new techniques were applied with remarkable success during the war to such problems as radar intereeption, and weapon development. A striking example occurred during the battle of the Atlantic, when aircraft were attacking U-Boats by dropping depth charges set to explode at 100 feet. The low rate of successful kills led to a research investigation to determine the reason. The accepted tactics were based on the estimation that aircraft would attack the U-Boat about 40 seconds after its submergence, by which time the U-Boat, diving at the rate of 2 feet per second,

would be within the lethal range of the charge. Scientific analysis of operations, however, showed that in fact 76 per cent. of the attacks were made when the submarines had been submerged for less than 30 seconds. At the same time it was calculated that the three-dimensional " probability zone " in which the U-Boat might be found increased very rapidly with the time of submergence. Clearly, with charges set at 100 feet, the aircraft had little reasonable hope of success (the scientists estimated their chances at 1 in 1,000). If the depth charges could be designed to explode at 25 or 30 feet, the chances could be greatly increased. This argument was accepted by Coastal Command, and as a result of the shallower setting, the rate of successes went up dramatically until they reached 20 a month.

(*b*) *In the Civilian Field and Industry.* Since the war, operational research technique has been applied with equal success in the civilian and particularly in the industrial field. It is appropriate on a national scale, for a whole industry or for an individual company. The B.B.C. Listener Research organisation, which collects and tabulates thousands of daily samples of listeners' choice of programmes, and submits results to the programme planners for their future guidance, is an excellent example on the national level. The Ministry of Agriculture regularly analyses how far the knowledge of scientific research is being applied by farmers, and thus obtains the basis for part of its educational and control schemes.

The importance of using these new methods for the improvement of industrial productivity was emphasised in the first report of the Lord President's Committee on Industrial Productivity published in April, 1949. The report advocated a great extension of this type of research, particularly as it was often productive of useful results in a reasonably short time, and a permanent Panel of the Committee has been set up to study its future possibilities. The increased use of operational research by industry does not of course mean that science should become commercialised, but rather that industry should become " science-minded," and willing to tackle its problems with the help of sound scientific method.

Examples : (i) *The Cotton Industry.* Pioneer work has already been done along these lines by many industrial research associations. Members will probably be aware of the experimental studies undertaken by the Shirley Institute into the existing wages and work load situation in the weaving industry, based on the Musgrave Mills experiment. Here it was found that inadequate labour forces and equipment could be compensated for by proper layout and motion study. The Institute's recommendations were adopted, as a result of which there was a 40 per cent. increase in P.M.H. The Shirley Institute are now undertaking further productivity

studies, comparing the operative hours per unit of production over a number of mills, in order to find out what differences in equipment, practice, methods or other factors are responsible for differences in efficiency.

(ii) *The Boot and Shoe Industry.* Another interesting example of operational research is provided by the studies in foot measurement undertaken by the Boot and Shoe and Allied Trades Research Association, and described fully in the Boot and Shoe Industry Working Party Report. It was the usual practice to grade shoe lasts for women's shoes by increasing the joint girth by quarter inch for every whole size. It was found that this led to much misfitting and waste of stock, expecially in sizes much above or below the average. The Research Association took a very wide survey of foot measurements, and found after analysing the data that the joint girths increased on an average by three-twentieths of an inch instead of quarter inch. Acting on this research, the industry is gradually adopting a much more accurate grading of lasts, with the effect that better fits will be ensured without a multiplicity of sizes and fittings, to the great economic advantage of the industry as a whole.

(iii) *Sociological Research.* The methods of operational research can equally well be applied by economists and social scientists in the field of human relations. Reference is made in the Committee on Industrial Productivity's Report to the work of the Tavistock Institute which is carrying out an intensive study of human relations over a long period in an engineering factory with 1,500 employees. Here the research team are not trying to solve a particular problem, but the knowledge gained from their research and the light it throws on methods of co-operative working may well be applied by other companies to improve relations within their own organisation.

(iv) *Market Research.* The modern technique of market research, involving the collection of a great quantity of factual information concerning local conditions and records of consumer demand, which are sifted and collated for the better guidance of the producer, presents many of the characteristics of operational research at the level of the individual firm. In fact, the whole conception of "scientific management," as a science which can be taught to its practitioners, implies that management's decisions ought to rest on such a factual and scientific basis rather than on intuition or guesswork.

(v) *Steel Inspection Tests.* Here is a much simpler example from the engineering industry, which shows the value of operational research when applied to the kind of problem likely to be encountered by production engineers. At a certain steel rolling mill, inspections

of finished steel bars were made, in accordance with common practice, at the end of a series of operations starting with the raw steel billet. Rejects at the final stage were costly, and it was desired to detect faults at an earlier stage in the manufacture. A close statistical analysis coupled with certain trial runs showed that it would be possible to do this for several of the major types of faults, and the cost of the rejects has now been reduced to less than half without in any way lowering the standard. Furthermore, it was found possible to eliminate certain of the final inspection tests as they were now covered by the earlier tests, and yet the total inspection effort was not increased. The research simply indicated the need for redeployment of the inspection effort.

APPLICATION TO PRODUCTION ENGINEERING

From these various examples it will be realised that certain functions and techniques commonly employed by the Production Engineer have a close affinity with the methods of operational research. The degree of development of the technique will depend on the complexity of the problem to be studied. Production Engineers are therefore well qualified to undertake research of this kind, particularly when it is directed towards the improvement of productive efficiency. Furthermore, it is most appropriate that the Institution should be thinking along these lines at a time when the maintenance of our present living standards and the restoration of a healthy economic position depend on greater productivity as a means to greater output.

(*a*) *Research Work Undertaken by the Institution.* The Research Committee of the Institution has selected for immediate study two problems which are very suitable for treatment by operational research methods. These are :

(i) Measurement of Productivity.

(ii) Materials Handling.

The Research Committee is making itself responsible for conducting studies and promoting conferences on materials handling and has delegated responsibility for the productivity measurement investigation to the Joint Committee of the Institution of Production Engineers and Institute of Cost and Works Accountants set up in January, 1949. It is confidently expected that this co-operation between the two Institutions will be most fruitful. The professional knowledge of both production engineers and cost accountants, working as a team, has been pooled for the pursuit of a common end, and the methods used in the early pilot investigation carried out by the Joint Committee last year were the methods of operational research in the strict sense. Naturally the work of the Joint Committee has been limited by virtue of the fact that it consists entirely of voluntary members, many of whom are busy executives ;

and it cannot be expected that the Committee will make substantial progress until it has the services of a full-time Research Officer. In the meantime the I.C.W.A. have allowed their Technical Officer to join the Committee, and he is able to undertake a certain amount of field work on behalf of the Joint Committee.

The Joint Committee is investigating the whole subject of measuring productivity along a number of separate lines; the I.C.W.A. members are now undertaking a study of machine utilisation, while the I.Prod.E. is following up the recommendations outlined in the Interim Report concerning the improvement of time study practice through a uniform training scheme. For this purpose an approach has been made by the Chairman of the Research Committee to all Sections, asking them to encourage their members to form working groups. These groups will endeavour to determine the best and most generally acceptable time study practice, and their contributions will eventually form the basis for a comprehensive standard curriculum for the teaching of Time Study. In this way the task of collecting data on which a sound factual conclusion can be based will be shared amongst a large cross-section of the Institution's members, who will thus be playing an important part in the total research effort of the Institution.

(*b*) *Collaboration with the University of Birmingham.* The Joint Committee is collaborating with the Department of Engineering Production at the University of Birmingham in a national investigation into work measurement. The University's Work Measurement Research Unit is an operational research team in the strict sense, and includes a trained statistician. A pilot survey of Time Study rating practice has already been completed, and arrangements are in hand for a national survey covering some four hundred firms. The Survey will not be confined to the engineering industry, but will cover many other industries in which Time Study is still the exception rather than the rule.

(*c*) *Liaison with Other Bodies.* The Research Committee is in touch, through the Joint Committee, with a number of bodies who are working on other aspects of productivity measurement. The Institute of Industrial Technicians, the professional body catering for Time Study engineers, is being asked to make a contribution to the Time Study training scheme. The Joint Committee is also aware of the work on Time Study practice being undertaken at Acton Technical College. Close liaison is being maintained with the Anglo-American Council on Productivity, who are regularly represented at meetings of the Joint Committee, and an exchange of views has already taken place under the auspices of the Anglo-American Council between the Joint Committee and the various other professional bodies and Research Associations who are studying the same subject.

PROSPECTS FOR THE FUTURE

(*a*) *Appointment of a Research Officer.* Council have already recognised the necessity for a Research Officer whose time will be solely devoted to developing and intensifying the Institution's research activities, and have given approval for the appointment to be made in due course. It is hoped that this appointment will achieve for research the fine results already brought about in the field of Technical Education by the Institution's Education Officer.

(*b*) *Contribution by the Institution's Membership.* Even with the appointment of a full-time Research Officer, it is vitally important that the research work of the Institution should be spread over a broad field, and that as many members as possible should contribute, in order that some concrete progress may be made. The national need for a marked increase in productivity is too well known for further emphasis here, but the Institution must endeavour to make a contribution at once. The research activities described above can bring about an increase in productivity, only if these investigations are successfully concluded within a reasonably short period, so that the greater task of persuading industry as a whole to accept and implement the results can be put in hand.

It is a characteristic of operational research that the research team should make positive recommendations, and, wherever possible, see them carried through. If this is not done, the effort spent on research work may well be wasted. The work now being done must therefore be the immediate concern of the Institution's members since they will have a major part to play in implementing any recommendations that may be made.

The form of research that the Institution is undertaking relies particularly upon the active assistance of a large number of members and affiliated firms. We are sure all our Sections and members will play an active part in collaborating with the Research Committee in all our future research activities.

WALTER C. PUCKEY,
Chairman of Council and
Chairman of Research Committee.

INSTITUTION NOTES

July, 1950

MEETING OF COUNCIL The next Meeting of Council will be held at 11 a.m., on Thursday, 27th July, 1950, at 36, Portman Square, London, W.1.

INSTITUTION DINNER The Institution Dinner is to be held on Wednesday, 4th October, 1950, at the Dorchester Hotel, Park Lane, London, W.1, when the President of the Board of Trade will be the Institution's Guest of Honour.

Members wishing to attend the Dinner are asked to make early application for tickets. (Evening Dress with decorations, or Dinner Jackets.) An Application Form for tickets was enclosed with the May Journal.

BIRTHDAY HONOURS, 1950 The Institution offers sincere congratulations to Mr. H. H. Harley, Member, Chairman of Coventry Gauge and Tool Company, and Mr. C. B. Colston, Chairman and Managing Director of Hoover, Ltd., who have been created Knights Bachelor, and to Mr. F. Hearle, Member, of the De Havilland Aircraft Company, Ltd., who has been awarded a C.B.E.

MEASUREMENT OF PRODUCTIVITY Members may find of interest the following extracts from an article on productivity of labour, published by the International Labour Office, Geneva, in I.L.O. News Service (Special Issue), 1950.

" David A. Morse, Director-General of the International Labour Office, has made public the terms of a proposal to reduce the risk of war through a world-wide sharing of techniques to increase labour productivity.

" Mr. Morse declared that higher living standards resulting from greater productivity were needed in the highly-industrialised countries as well as in the world's less developed regions. His proposal is in the form of a section of his annual report to the 33rd I.L.O. conference opening at the Palais des Nations, Geneva, June 7th. He has invited the worker, employer and government delegates of 60 member countries to debate it at that time.

" . . . Mr. Morse expressed the hope that the work of the I.L.O. Conference of Labour Statisticians would ' lead to international agreement on the methods by which labour productivity can be best measured.'

I.L.O. is Ready

" He suggested various studies which the I.L.O. technical services were best equipped to undertake on an international basis, including the following :

(1) A factual and analytical study of factors affecting the productivity of labour in under-developed countries.

(2) A study of possible ways and means of extending systems of payment by results.

(3) An examination of the scientific basis of methods of work simplification based on time and motion studies, and their effects on output.

(4) A study of the conditions for and advantages of greater standardisation of production.

(5) A study of ways of organising double shifts and their advantages and disadvantages.

(6) A study of ways and means of promoting the rapid spread of improvements in techniques of production and management.

Mr. Morse said :

" If economic welfare requires that productivity-raising changes in production and managerial techniques should not be resisted, it requires also that they should be introduced in such a way as to involve a minimum of hardship for individuals. This, too, might form the subject of a comprehensive study."

His conclusions included the following :

" . . . A full employment policy may need to be accompanied by measures to ensure that practices which impede the effective use of incentives, and inhibit ready response to incentives, are discontinued.

" Even more important, perhaps, the effects of full employment on productivity will depend largely upon how far workers and their leaders are able to substitute self-discipline and a sense of responsibility for the discipline of fear.

" Efficient management has much to contribute to the growth of productivity.

" A united determination to increase productivity can be created and maintained only through the fullest understanding by employers and workers of each others' points of view ; it can be carried into effect only by the closest co-operation between them.

" To the extent that greater productivity leads to lower prices, the advantages it brings are shared among all members of the community."

CONFERENCE ON INDUSTRIAL STATISTICS

The Industrial Applications Section of the Royal Statistical Society is arranging a Conference on Industrial Statistics at the University of Sheffield from Friday, 29th September, to Sunday, 1st October, 1950.

The aim of the Conference is not only to extend the scope of statistics in its application to industrial problems, but also to pro-

mote the free exchange of ideas between those who have interests in this field. One session of the Conference will be devoted to "Statistics Invades Time Study," when Mr. D. J. Desmond, of the Work Measurement Research Unit of the University of Birmingham, will describe methods of analysis to be used in the forthcoming survey of Time Study Rating Practice.

Full particulars may be obtained from the Hon. Secretary of the Section Committee, at the G.E.C. Research Laboratories, East Lane, North Wembley, Middlesex, or from Mr. G. H. Jowett, the Sheffield Conference Secretary, at the University of Sheffield.

EDUCATIONAL APPOINTMENTS Applications are invited by the Huddersfield Technical College for the post of lecturer in the Department of Civil and Mechanical Engineering, qualified particularly in Production Engineering, and able to supervise instruction in the workshops. Preference will be given to candidates with suitable qualifications such as Corporate Membership of either the Institution of Mechanical Engineers or the Institution of Production Engineers. Good industrial experience is essential and ability to teach Metrology is desirable. Salary will be in accordance with the Burnham Scale, with additions for qualifications, training, and industrial experience.

Duties will commence on 1st September, 1950, or as soon as possible thereafter. Forms of application may be obtained from The Principal, Technical College, Queen Street South, Huddersfield.

Applications are also invited for the post of full-time Teacher of Engineering Workshop subjects at The Walker Technical College, Hartshill, Oakengates, Shropshire. Teaching duty will be divided between City and Guilds Machine Shop and National Certificate courses, and Secondary Technical workshop classes. Applicants should hold a qualification appropriate to the work, and should have had adequate industrial experience in the use of machine tools. Salary will be in accordance with the Burnham Scale.

Applicants should give age, education, qualifications, teaching and industrial experience, with dates, together with copies of two testimonials and the names and addresses of two referees, and should be forwarded to reach the Principal of the College as soon as possible.

NEWS OF SECTIONS The Institution is pleased to record considerable progress in two of its Sections. At the recent Meeting of Council Lincoln Sub-Section was raised to full Section status, and in Liverpool, a Graduate Section has now been formed. All members will join with the Institution in wishing these Sections continued success in the future.

The Hon. Secretary of the Northern Ireland Section, Mr. W. G. Wyman, would be glad to hear from any members of the Institution

who intend visiting Northern Ireland during the 1950/51 Session, and who might be prepared to give a paper to the Section in Belfast.

NEWS OF MEMBERS

Mr. M. E. Bell, Associate Member, has joined Associated Industrial Consultants, London, as a resident Consultant.

Dr. J. W. Bondi, Member, has joined the Board of Associated British Oil Engines, Ltd., London.

Mr. R. H. Buckland, Member, Works Manager of Leys Malleable Castings Co. Ltd., Derby, has been appointed a Director of the Company.

Mr. W. Castledine, Associate Member, is now Planning Engineer and Apprentice Supervisor with Salopian Engineers Ltd., Prees, Whitechurch.

Capt. C. H. Codling, Associate Member, has been appointed Assistant Works Manager at the Nigerian Government Railways Locomotive Works, Enugu, Nigeria.

Mr. J. A. T. Crump, Associate Member, is now Works Engineer to United Wire Works (Birmingham) Ltd.

Mr. J. S. Murphy, Associate Member, is now Editor of "Manufacturing and Management," published by the Tait Book Co. Ltd., Melbourne.

Mr. W. L. Oddy, Associate Member, has been appointed Technical Representative of Manchester Oil Refinery Sales Ltd., for the South side of the Thames.

Mr. L. F. Oliver, Associate Member, has joined Wilmot-Breeden Ltd., Tyseley, Birmingham, as Production Manager.

Mr. J. Robertson, Associate Member, has been appointed Chief Process Engineer at Brush Electrical Engineering Co. Ltd.

Sir Rowland Smith, Member, has been elected Chairman of The Ford Motor Co., Dagenham.

OBITUARY The Institution deeply regrets to announce the deaths of Mr. I. F. Bellringer, Associate Member, of Manchester Section; and Mr. F. E. Brierley, Member, of Preston Section.

BOOKS RECEIVED "Resistance Welding in Mass Production," by A. J. Hipperson, B.Sc.(Eng.), A.M.Inst.W., and T. Watson, M.Inst.W. Iliffe & Sons, Ltd., London. Price 21/- net.

This book covers a very wide field in the application of Resistance Welding technique in its various forms. Chapters are devoted to each process with illustrations of equipment and its applications

including Spot Welding, Projection Welding, Seam Welding, Flash and Butt Welding, hot riveting, testing and inspection of welded joints.

Many useful charts are included together with suggested designs for electrodes, jigs and fixtures with many examples and their applications.

The final chapter deals with Resistance Welding costs. Those interested in the science of welding will find this book a very useful reference to have at hand, and students will find it extremely helpful. A.R.

"Diamond Tool Patents IIIS—Truing of Grinding Wheels," by W. Jacobsohn, A.M.I.Mech.E. Industrial Diamond Information Bureau, London. Price 7/6 net.

IMPORTANT In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

ISSUE OF JOURNAL Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

MODERN FOUNDRY PRACTICE

by C. S. JOHNSON, B.Sc., A.I.M.

Presented to the Preston Section of the Institution, March 1st, 1950

In the foundry industry over the past twenty or thirty years great strides have been made in producing castings of high quality at economical prices, and in the quantities desired, with an ever-increasing shortage of skilled labour. This is especially true in the automobile industry, where the foundries have had the difficult task of keeping pace with the demand for castings of ever-increasing complexity and quantity as the industry grew, and greater efficiencies and lower costs were, and are, constantly being striven after by the automobile engineers.

As it has always been the tendency for the automobile foundries to lead the rest of the foundry industry, it is inevitable that in discussing modern practice many of my remarks will be directed towards this type of foundry, although they will be kept as broad as possible. In the field of light alloys, the manufacture of aircraft castings, a development of automobile practice, was given a tremendous impetus during the War and now represents the most modern achievements in technique in this sphere.

Owing to the nature of the various metallurgical factors in founding, involving as they do complex chemical and physical

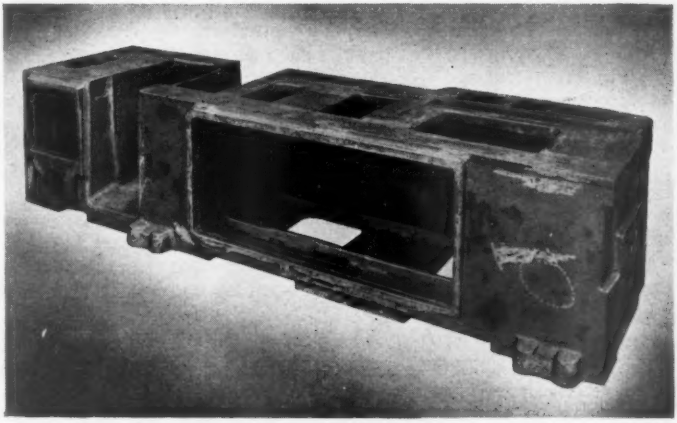

FIG. 1. Aluminium alloy lathe bed casting (wt. 1,450 lb. approx.).

The Institution of Production Engineers does not accept responsibility for any statements made or opinions expressed in any papers published in the Journal of the Institution.

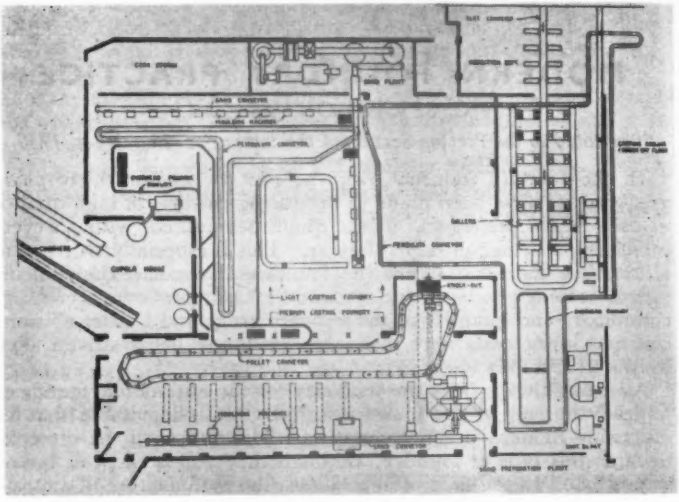

FIG. 2. Layout of mechanised iron foundries.

changes, and because of many other variables in moulding and casting which are difficult to control with the accuracy of precision machining operations, it follows that particularly in the absence of skilled craftsmanship, relatively intensive technical control and supervision is required compared to most other engineering processes. Such control is now an established feature of modern practice.

In many instances, by the development of new or improved materials and processes, the foundryman has been able to offer the possibilities of further advantages to the engineer, in the way of weight-saving, reduced machining costs, etc. The introduction of oil-bonded sand cores is now an old example and the newly-developed nodular cast iron is another.

One of the more important developments of recent years has been the increasing co-operation between engineers and foundrymen, particularly in the designing stage, by which means many potential difficulties can be obviated with an increase in all-round efficiency.

MECHANISATION The shortage of skilled labour and the demand for larger quantities of castings have led to the use of mechanised methods and to more specialisation of production. The principles of mechanisation are essentially the same in all industries and in the foundry; in order to utilise unskilled or

semi-skilled labour and to take full advantage of mechanisation, the castings production is split into many limited operations, each being made as foolproof as possible. In this way, a team of specialists is built up, each individual being adept in one particular phase of the operations, such as moulding machine operation, core setting, closing, casting, etc., thus leading to vastly higher rates of production. The quality is usually maintained and may be improved where the control methods are adequate, for the greater use of mechanisation tends to greater precision, particularly in moulding. It is obvious that as the degree of mechanisation increases, so must the control over the production become more exacting, for as the rate of production increases so can the rate of production of water castings increase should anything go wrong. This is not such a grim prospect as might be imagined, however, for the use of mechanical methods facilitates the application of control.

As mechanisation and standardisation of equipment and methods go hand in hand, the greater use of mechanisation tends to inflexibility in the range of castings which can be produced, and one is forced more and more to specialise. In some foundries, particularly those attached to engineering works, the range of work may be limited, and this produces few difficulties. In other cases, and particularly in unattached foundries, flexibility is very

FIG. 3. Mechanical cupola charger—scale car and bins for raw materials.

important and if it is attempted complete mechanisation must take the form of two or more units covering a particular range of production. Even then a good deal of production planning is necessary in fitting in smaller numbers off.

One of the most serious limiting factors in the mechanised production of high duty iron castings is the supply of the different grades of molten cast iron, which are necessary to suit the various different types of casting, as explained later.

Foundries making larger castings do not lend themselves to such complete mechanisation, and here the advances have been mainly in the use of some type of mechanised sand handling, and also sand slingers, (which cut down enormously the time taken for ramming up), and in better metallurgical control.

In the field of aluminium castings there is now a definite preference for die castings wherever the cost of a die can be justified, and for this reason aluminium foundries are not usually mechanised to the same extent as iron foundries, for the majority of castings suitable for machine moulding may be die cast with advantage.

Before passing from the general review of mechanisation, it must be pointed out that in foundries it is unusual for mechanisation appreciably to cheapen production in comparison to floor moulding, and it more commonly merely increases productivity per man or unit of floor space.

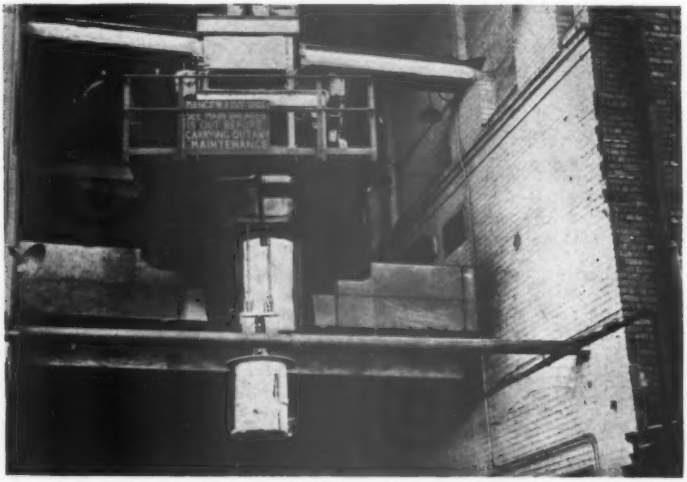

FIG. 4. Mechanical cupola charger—automatic hoist.

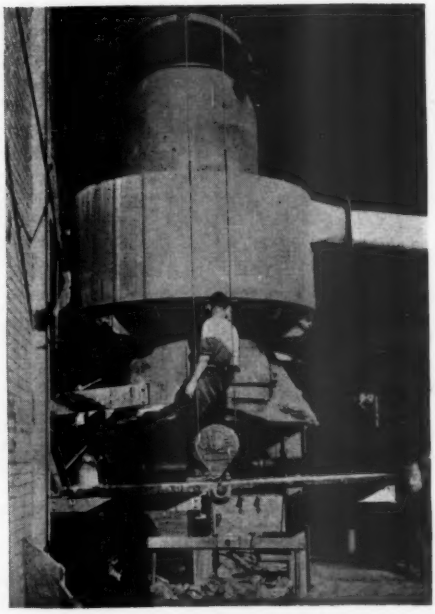

FIG. 5.
View of bottom of 43″ I.D. cupola.

ORGANISATION METHODS The means of obtaining the consistently high quality at economical prices demanded of the foundry by the engineer are resolved into five categories :

(1) Overall efficiency.

(2) Good pattern and moulding box equipment.

(3) Good metallurgical control.

(4) Good inspection.

(5) Good supervision and maintenance of plant.

The first requirement is of course supreme, and embraces all the other four main factors. In these days of more or less universally exchanged technical knowledge, it is only in the application of this knowledge with the maximum efficiency in every phase of foundry organisation that the increasing competition can be profitably met.

In this connection a positive costing control system, such as Standard Costing, is a helpful tool in obtaining maximum efficiency as by this means all inefficiencies can be pinpointed.

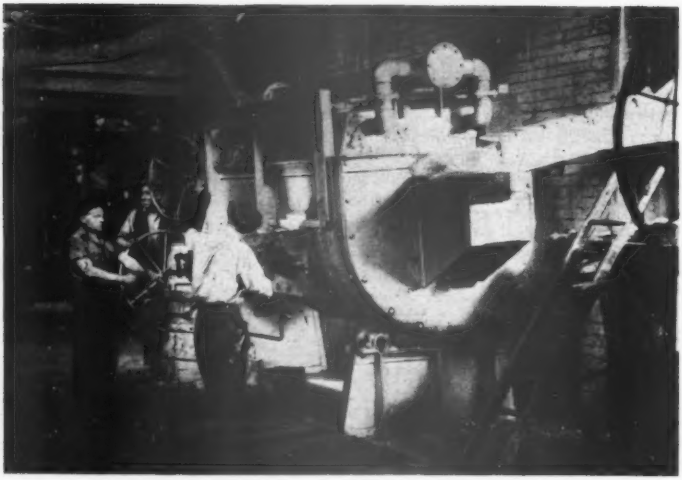

FIG. 6. Oil-fired metal receiver with iron being tapped in continuously through Freier-Grunder spout.

With regard to the second requirement, metal pattern and corebox equipment is used wherever possible, where the quantities off are large enough to warrant the expense, and are designed to give the quickest and safest production. Unfortunately it is too often the case that wooden pattern equipments for experimental or small quantity production are used longer than was originally foreseen, with a consequent deterioration in quality in the castings. As a casting at the best is only as good as the pattern, the maximum of thought and skill must be put into the manufacture of this equipment.

The moulding box equipment must be rigid enough to give full support to the sand and to be dimensionally stable under the rather severe handling conditions. For mechanised production it is essential that they be fitted with hardened raised bushes, one of which should be elongated, and it is advisable that they be jig-drilled. A regular inspection of moulding boxes is usually carried out, and a separate Box Hospital may be provided.

The degree of metallurgical control necessary varies with the type of metal melted, being much greater with cast iron and steel. It also increases markedly with the rate of production and the complexity of the castings being made, in common with all the other types of control. The control of the moulding and core sands, too, is always classed as a metallurgical function.

In high duty iron foundries the chemical composition of the metal has to be suited to the sectional thickness of the castings being made and to the type of service ultimately required of the castings. This is because of the pronounced effect of cooling rate upon the mode of occurrence of the carbon in the resultant castings. With a fast rate of cooling in thin sections or with low carbon and silicon contents, the carbon does not fully separate out and stays as hard iron carbide ; in other words, the castings are chilled. Conversely, with a slow rate of cooling in thicker sections, or with too high carbon and silicon contents, the carbon separates out as coarse graphite flakes and the castings are relatively weak and open grained. (Figs. 10, 11 and 12.)

Owing to this need for suiting the metal composition to the job to be cast in high duty iron foundries, it is necessary to group the castings according to the most suitable grade of iron. On a fast mechanised line, only one grade of iron can be satisfactorily cast at the same time, and because of this a good deal of production planning is required.

In foundries where really close control of the iron analysis is necessary as in the case of automobile foundries, this control is

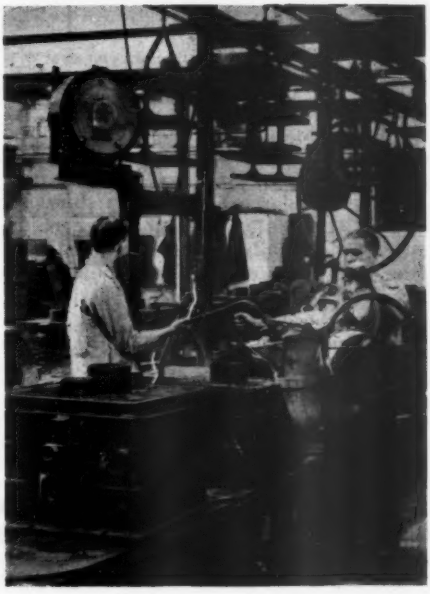

FIG. 7.
Checking molten iron temperature, using amplifier and large illuminated dial indicator.

FIG. 8. Castings on the pendulum conveyor of a light castings mechanised iron foundry (speed of travel approx. 20 ft./min.).

applied right at the source at the pig iron suppliers, by purchasing to narrow specifications, and is continued right through the process until the iron is cast. Fig. 13 shows the cupola charge instruction for a particular grade of high duty iron calculated to give the desired chemical composition after melting. Fig. 14 illustrates the type of rapid chill test specimens which are poured from the molten iron before casting into the moulds, and are used to indicate the degree of hardness of the iron, and supplement the usual chemical analysis checks.

The metallurgical aspect of the founding of non-ferrous alloys and steel is not quite so complicated in this direction, for no modification of chemical analysis is necessary for different sectional thicknesses, and one alloy can be cast into moulds for castings of any size. In addition, the non-ferrous metals are usually purchased ready alloyed and there are no appreciable changes in composition during melting.

The control of the molten metal supply in aluminium founding is limited to the strict application of temperature control, and to the avoidance or removal of dissolved gas during melting in sand foundry practice. In the case of die casting, it is helpful in certain

FIG. 9. View of medium castings mechanised iron foundry, showing pallet conveyor in foreground.

instances deliberately to dissolve gas into the metal to minimise local shrinkage and hot tearing. This is not detrimental in the finished casting, for fast rates of solidification as in die casting cause the gas to be retained in the metal in solution, or to be so finely dispersed as to be invisible upon machining. In the case of sand casting with the slower cooling rates any appreciable amounts of gas give rise to pinhole porosity, which shows up uniformly scattered over machined surfaces.

In the modern foundry, castings inspection is very highly developed and it serves two purposes :

(1) To ensure, as far as it is possible, that the castings which are despatched to the customer are of at least the standard of quality desired, by this means protecting both the customer and the foundry's reputation.

(2) To enable any detectable faults to be recognised quickly and to be corrected with the minimum of delay.

With regard to the first, an important tendency is arising in that some of the preliminary operations of machining are now beginning to be carried out by the foundry. In particular, equalising jigging

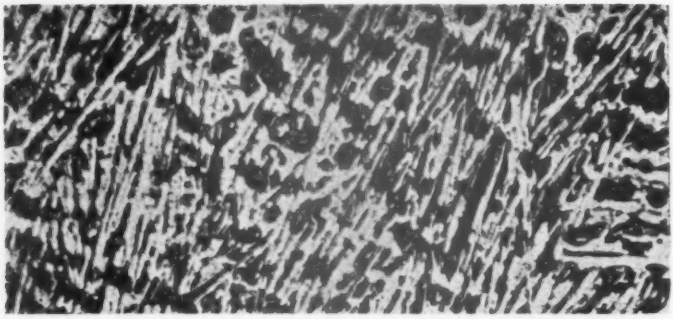

FIG. 10. Iron composition too hard for section thickness—chilled structure (x 500).

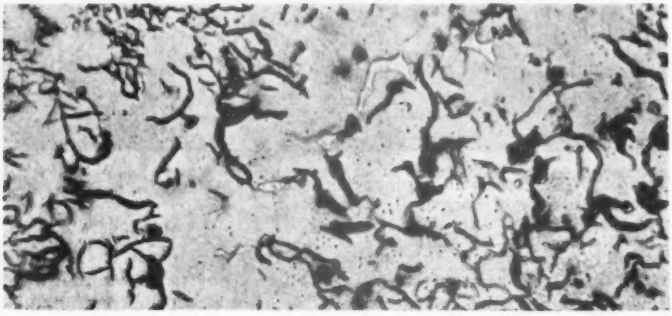

FIG. 11. Iron composition correct for section thickness—fine graphite (x 500).

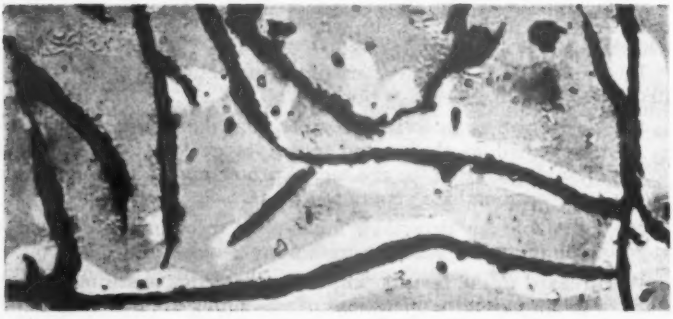

FIG. 12. Iron cast into too thick a section—coarse graphite (x 250).

CHARGE — FURNACE COPY

GRADE 'A' (REFINED) Mix No. M984 Date 29-3-49

%	BIN No.	BRAND	CWTS.	QTRS.	LBS.	Remarks
		BEAR PARK COKE	1	0	14	
		LIMESTONE		1	12	
15		STEEL SCRAP	1	0	6	
50		SPECIAL REFINED	3	2	0	
30		GRADE 'A' RETURN SCRAP	2	0	12	
5		BLUE CHROME PIG		1	10	
		SILICON BRICKS	NONE			
		MANGANESE BRICKS	NONE			
		TOTAL METAL	7	0	0	

FIG. 13. Cupola mixture instructions.

and spot location of more complicated castings by the foundry are becoming more common. For instance, in cylinder block manufacture, the castings supplied to the machine shops can be inserted straight into the machining jigs with the certainty that they will machine up satisfactorily to dimensions. In some foundries, too, rough machining may be performed on certain suitable types of casting. By these means, the machine shop is further protected against the possibility of wastage of machining time due to faulty castings, and once again any trouble can be detected and put right in the foundry with the minimum of delay. Such methods are of course more readily applicable in the production of repetition castings.

In casting equalising, the principle is that a number of templates are accurately located to one another, corresponding to all the main points likely to vary. The casting is inserted between them and adjusted in all planes until a satisfactory allowance for machining at all points, and the best average of all other important dimensional variables, are obtained, with respect to the templates and any supplementary gauges.

Having obtained this, sufficient location points are made by drilling and spot facing to allow the casting to be set up immediately in the machining jigs in exactly the same position. Three spot-faced location points, two of which are drilled for dowel holes, are the

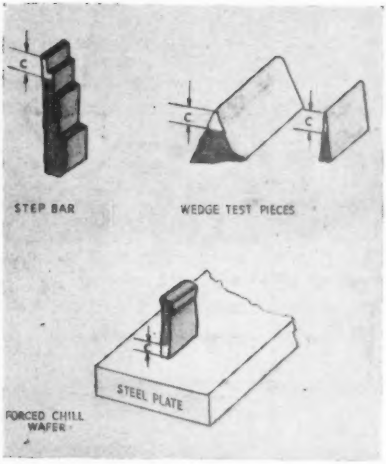

FIG. 14.
Wedge chill test pieces.

best arrangement and these are all put on one face. In the absence of the dowel holes, sufficient spot-faced location points on three faces are necessary. Fig. 15 shows a hand-operated jig for a gear box.

With fast rates of production it is vital that inspection of the castings should keep right up with production in order that the inspection can be used to help the production department to correct faults as they arise, or even to detect undesirable tendencies before they can cause scrap, instead of acting as a disinterested mechanical "go" or "no go" scrap detecting machine some days after the castings are made.

This is so important that it is the practice on the mechanised iron plants in the foundries with which the author is associated, to have a rough inspection—including a percentage dimensional check on some castings—on the knockout, while the castings are bright red hot. A second rough inspection is carried out after the castings have been shot blasted, usually within an hour or two of casting, and a final 100 per cent. inspection is performed after trimming. This serves the double purpose of the earliest possible detection of any undesirable tendencies, and also cuts out wasted trimming time on defective castings.

During the recent war, radiographic methods of inspection were developed to a very great extent and are now well established as an important factor in improving quality and also, by helping to minimise rejections, in cutting costs. The shrinkage of light alloys

makes the X-ray inspection of castings in these metals especially desirable, to ensure that the foundry technique produces castings of a satisfactory degree of freedom from internal unsoundness. Their low density makes the use of radiographic inspection relatively easy. Most aircraft castings are completely X-rayed all over, and must be free from any but very minor unsoundness. For the usual run of commercial production, however, this would be uneconomical, and a percentage check is taken after the initial technique has been proved by more extensive examination. The use of radiographical examination is now also becoming extensively applied to steel castings, steel also having a high shrinkage on solidification. Fig. 16 shows a casting being set up for examination under a 200 k.v. set, while Fig. 17 is of a radiograph showing a bad area of internal unsoundness in an aluminium alloy flywheel housing casting.

Not much can be said on the subject of supervision as the number of foremen, chargehands, and gang leaders or working chargehands required varies greatly with the type of production, and extent of mechanisation.

Maintenance plays a very important part in mechanised production, as the conditions under which plants have to operate in a foundry are the very worst possible. Consequently maintenance costs are high and a very high standard of preventive maintenance is required to keep a plant running efficiently. Any attempt to

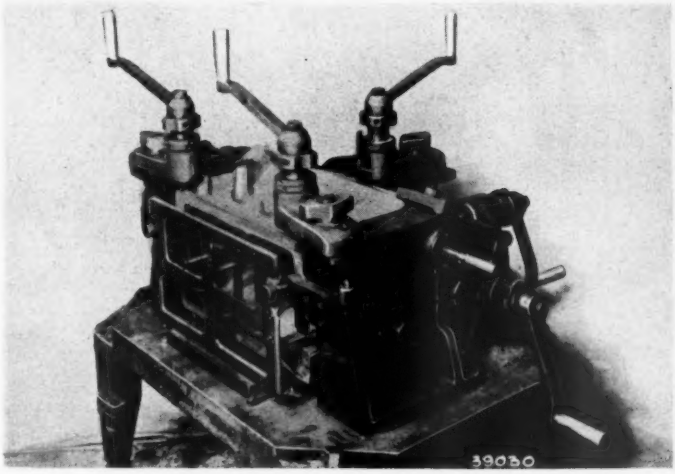

Fig. 15. Hand-operated equalising and spot facing jig for gearbox casting.

cut costs by reducing the expenditure on this type of maintenance to the degree where it must be skimped, is fatal and very short sighted.

IMPROVED METHODS OF PRODUCTION

With regard to production methods, there have been considerable developments in the gravity and pressure die casting of light alloys as indicated previously, and wherever the quantities warrant the capital expense of a die, gravity die castings are now preferred to sand castings because of their relative cheapness, greater dimensional accuracy and better finish, and pressure die castings are preferred to gravity die castings, where feasible, for the same reasons. Many aluminium and magnesium alloys are gravity die cast, but probably the most popular pressure die casting alloys are the zinc base alloys, owing to their low melting point coupled with moderate strength.

Ferrous die casting, long established in a simple form as a method of centrifugally casting iron pipes and automobile cylinder liners, has also been developed to a fairly considerable extent, for the production of less specialised castings of designs suitable for the manufacture and economical working of the dies. The severe conditions imposed on the dies due to the relatively high casting temperatures necessary are the limiting factors in the die casting of iron.

FIG. 16. 200 KV X-ray set. Casting being set up for examination.

In the field of small castings in a wide range of metals and alloys considerable progress has been made in precision casting based on the old lost wax process. In this process, very accurate metal dies are used for the production of equally accurate patterns in wax or frozen mercury. The patterns are compacted in very fine refractory material by vibration in a suspension of the material, and the resulting mould dried and baked, during which process the pattern melts out. The molten metal is usually forced into the cavity and the ensuing casting very accurately maintains the dimensions of the pattern, and it is possible to cast small articles requiring little or no machining.

A recent modification of this process, the Osborne Shaw process, is more suited to the repetition production of miscellaneous castings. The castings made are usually fairly small, as the cost of the process tends to be more uneconomical on larger castings.

The advent of core-blowing has considerably speeded up and cheapened core making. In the blowing machine the core sand is carried into the core box by means of compressed air, and even quite large and intricate core boxes can be filled in a few seconds with a suitable type of machine. Cores weighing 50 to 70 lbs. are quite commonly blown.

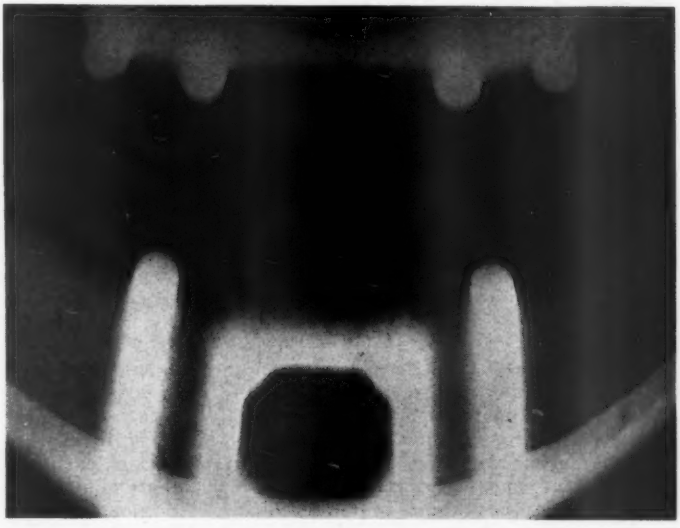

FIG. 17. Radiograph of flywheel housing casting in aluminium alloy.

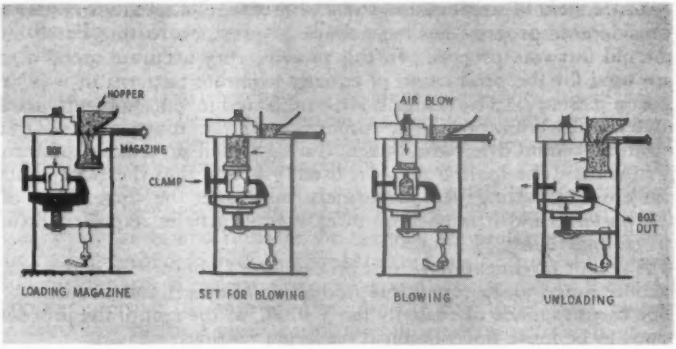

FIG. 18. Illustrating the principle of operation of a core blower.

The resultant cores are also more evenly rammed and of a very high quality. The blowing machine can be adapted to the production of a wide range of cores, but it is especially suitable for the high-speed production of cores of a repetition nature.

The capital cost of core box equipment suitable for blowing is higher than that for equipment for hand ramming, and the wear and tear is greater, but core making costs are very appreciably cut in almost all instances where the quantities are adequate, and in common with most other machines a core blower gives the cheapest production when fully manned up to the economic limit.

Fig. 18 shows the principle of the operation of a core blower, and Fig. 19 illustrates the core-blowing section of a core shop. A complicated water jacket core for a water-heated, die-cast aluminium inlet manifold for the Jaguar car would be very difficult to make by hand, but presents few difficulties in blowing. The resultant core is shown in Fig. 20, together with the main body core, and these are shown inserted in the die and die core in Fig. 21, which also shows the resultant casting. This is more clearly illustrated in Fig. 22.

There have also been developments in the greater application of scientific methods and controls, and there have been technical advances in the materials used, both sand and metal.

In the field of moulding sands for cast iron and steel, the advent of more mechanisation has inevitably led to the use of partly or fully synthetic sands where the moulding properties are maintained or imparted by the addition of powdered clay. Additions of starch are frequently made to such sands to impart additional plasticity. The addition of these agents is made necessary because of the

repeated circulation of the sand in a closed system from the mills, to the machines, and the knockout and back. In a fully mechanised continuous plant, one of these complete cycles may be made in as little as 45 minutes.

The improvements in moulding technique and in sand control have resulted in the possibility of working to closer limits and smaller machining allowances in machine moulding. An outstanding example is a 23 lb. brake drum in cast iron, which is regularly made with a machining allowance on the horizontally cast flat face of $\frac{1}{32}$" and is held to a tolerance of $+\frac{1}{32}$"—0".

As relatively small variations in the sand properties have an appreciable effect on a fast-working mechanised plant, they must be rigidly controlled. This control is based on conscientious and well-trained mixer operators, supplied with a simple form of testing apparatus for moisture determination, and also timing devices on batch mixers. This is backed up by a more complete system of testing every hour by the laboratory, where the permeability, strength, plasticity and coal dust content, together with the moisture content, are determined. The value in the results of these tests as for any other testing method lies in their immediate application in the foundry.

FIG. 19. View of part of a core shop blowing section.

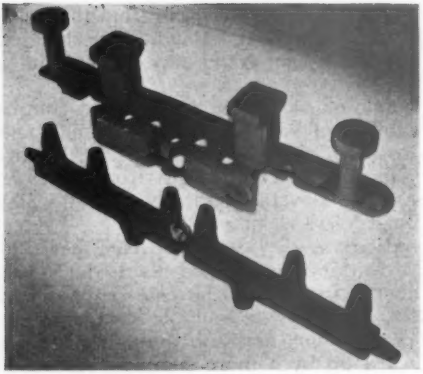

FIG. 20.
Water jacket and main cores for Jaguar water-heated inlet manifold.

FIG. 21.
Manifold cores inserted in die and die core, with casting showing runners and risers.

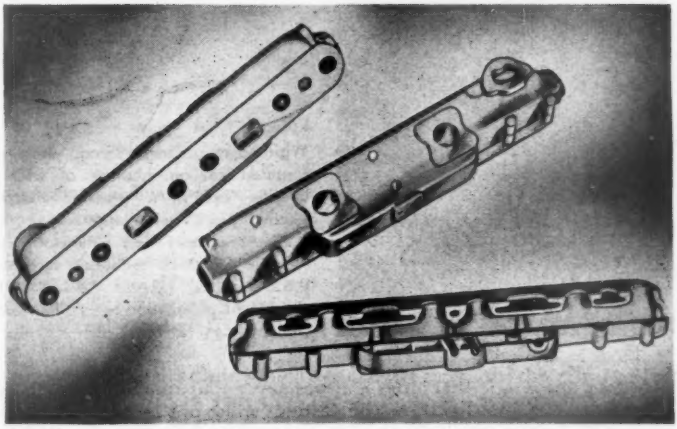

FIG. 22. Water-heated inlet manifold for Jaguar car.

Turning our attention to the metal, there was developed in the aluminium founding field, during the last war, a useful general purpose secondary alloy, D.T.D. 424, of a composition suited to the blending of the various types of scrap available. This alloy gives about 9 to 10 tons per square inch, and a small elongation of just under 2.0 per cent. The highest strength cast aluminium alloy is D.T.D. 304, with 4.5 per cent. copper, which after heat treatment gives about 20 tons per square inch tensile strength with 5 per cent. elongation. This alloy is used extensively for aircraft undercarriage parts, which are liable to be highly stressed. Other alloys are also available with various combinations of properties, and together with these two alloys form a series suitable for covering a very wide field of application.

Great strides have been made in increasing the strength of cast iron over the last few years, and it is now possible to produce cast iron of up to 30 tons per square inch by the use of inoculation and alloys to control the graphite shape and size, and to strengthen the matrix.

Generally speaking, increasing tensile is accompanied by increasing Brinell hardness, and the Brinell accompanying the strongest irons is usually around 300.

More often than not, however, we are asked to give castings which are easily machinable, and are not often asked to give super strengths with the accompanying high hardness. In the production of automobile parts, for instance, the use of rather elaborate fast-

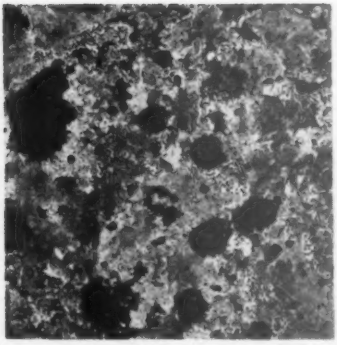

FIG. 23.
Whiteheart malleable iron, showing rounded carbon nodules of widely varying size in a pearlitic matrix (etched picric acid, approx. x 75). *Typical properties :* (on ½" section, not suitable for thick sections) 25 tons P.S.I. tensile ; 14 tons P.S.I. yield ; 9 per cent. elongation ; 5 ft./lb. Izod (notched .45" D bar).

working automatic machines is necessary to cut machining costs to the minimum, and for these the castings must not be unduly hard, and chilled corners are fatal (the usual range is 207 to 242 BHN). Strength is obtained where necessary by suitable design. This is so important that sometimes grey iron castings are even annealed to remove the pearlite altogether, and reduce the hardness to the absolute minimum.

A recent development of considerable interest and importance, referred to earlier, is the magnesium or cerium treatment of cast iron to produce a new range of super strength irons with moderate hardness and good machinability, which can be annealed to give very appreciable ductility. The effect of the treatment is to cause the graphite to crystallise in a spherulitic or nodular form instead of the usual flake form. If cast iron is described as a kind of steel

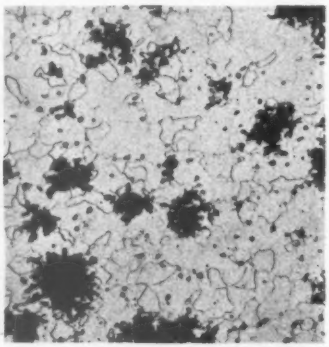

FIG. 24.
Blackheart malleable iron, showing irregular carbon nodules in a fully ferritic matrix (etched nitric acid, approx. x 150). *Typical Properties :* (B.S. 310 Grade 3) : 23 tons P.S.I. tensile ; 14 tons P.S.I. yield ; 18 per cent. elongation ; 10 ft./lb. Izod (notched .45" D bar).

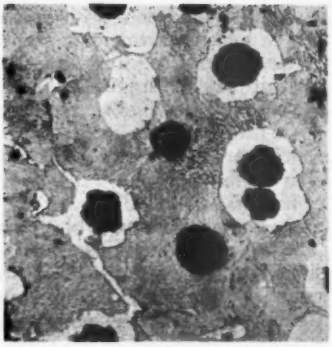

FIG. 25.
High impact nodular cast iron, as cast, showing graphite in the form of regularly shaped nodules, surrounded by ferrite in pearlitic matrix (etched picric acid x 150). *Typical Properties :* 40 tons P.S.I. tensile ; 2 per cent. elongation ; 3 ft./lb. Izod (notched .45″ D bar).

containing free graphite which reduces its strength, the effect of the nodular graphite in reducing the strength is very much less than that of the flake graphite. This is so pronounced that a haematite iron normally giving 8 to 10 tons per square inch tensile strength gives 40 tons per square inch after treatment with magnesium, with a Brinell hardness of about 250 to 280. After a short heat treatment this nodular iron gives a tensile and elongation of 25–30 tons per square inch, and 15–20 per cent. respectively. Alternatively, tensile strengths of up to 70–80 tons per square inch with little or no ductility can be obtained, by the use of alloys and suitable heat treatment.

The general quality of nodular iron castings as regards surface finish and dimensional accuracy is rather better than those in malleable or steel, owing to the lower casting temperatures used and shorter heat treatment.

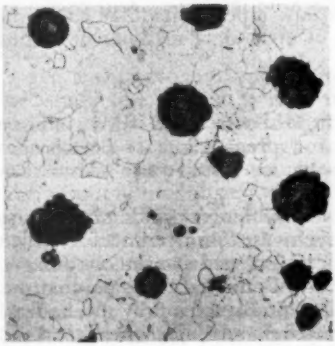

FIG. 26.
High impact nodular cast iron after heat treatment. Graphite nodules in 100 per cent. ferritic matrix (etched nitric acid x 150). *Typical Properties :* 27 tons P.S.I. tensile ; 19 tons P.S.I. yield ; 20 per cent. elongation ; 12ft./lb. Izod (notched .45″ D bar).

Nodular iron is sensitive to certain elements of its composition, which make it prone to a very low impact resistance in spite of its having a relatively high ductility, and if shock resistance is important, it must be specified. With correct chemical composition and control in production, nodular iron can be made economically, with properties including Izod impact value superior to those of blackheart malleable. The yield point is particularly superior to that of the latter.

Figures 23–26 illustrate the comparative micro-structures of high duty cast iron, whiteheart malleable, blackheart malleable, and as cast and heat-treated nodular cast iron, and show the similarity between malleable iron and nodular iron under the microscope. With the illustrations are given typical properties of the best grades of malleable and ductile nodular iron.

CONCLUSION The subject upon which I have been asked to speak is an extremely wide one, and I have only been able to mention briefly some of its aspects most likely to be of interest to you as engineers.

It will be apparent to you, however, that the main feature of modern practice is in the gradual development which has taken place in the use of mechanisation and all that this implies, particularly inspectional and technical control, with the result that in the medium and small castings foundries the vanishing craft of the moulder is being largely replaced by intelligent method planning and the skill and forethought of the pattern maker, in providing first-class pattern equipment for machine moulding, and by the exacting technical control. In the heavier foundries mechanisation is being used to make the most of the skilled labour available by cutting out the time taken on less skilled operations.

In the future, we can look forward to further developments in the die casting of iron and light alloys, in precision casting, on the commercial production of the various types of nodular cast iron, and in the more widespread use of up-to-date methods of casting jigging.

DISCUSSION

In opening the discussion, Mr. F. M. Kemp asked if Mr. Johnson would expand his remarks on sand preparation, as he felt that those present would be interested to learn more about this important aspect.

Mr. Johnson described the two different sand preparation systems used in his company's mechanised iron foundries, which were based respectively on batch mixers and continuous mixers, commenting on the methods of control adopted. He pointed out that the continuous system was only suitable for a fully mechanised plant on the production of relatively light castings, where the sand

could be used without a separate facing sand with reasonably good results. Where large tonnages of sand were involved, the capital expense of a continuous plant was less than that of batch mixing plant for a given output. The latter type was, in his opinion, essential for relatively heavily bonded sands, and for plants which were only partially mechanised.

Mr. RYDER asked what Mr. Johnson considered was the minimum amount of sand preparation necessary, and the type of plant which would be involved.

In reply, it was stated that the amount of preparation necessary depended of course upon the type of production, but the simplest form of sand preparation, for iron castings, was to use a backing sand prepared on the floor by means of an aerator, which gave a reasonable distribution of moisture, although the amount was difficult to control, there being a tendency to introduce an excess.

A facing sand, prepared in a batch mill, would provide a sand of satisfactory properties where it was most required, against the casting surface. This method was widely adopted, and it was the general practice to add all the new sand to the facing sand, which might contain 30 per cent. of new sand, or even more.

The Chairman, Mr. WESTALL, said that from the description and illustrations presented, a very good idea was obtained of the completeness of the mechanisation in the particular foundries described. He asked if Mr. Johnson could give some idea of the man-power saved by mechanisation.

Mr. JOHNSON said this was a difficult question to answer, but to give some idea of the manpower involved in the foundries described, this was approximately 300 for an output of 180 tons per week. This included supervision and inspection staff.

Mr. E. KEMP, to supplement Mr. Johnson's answer, said that before the introduction of mechanisation 100 boxes per day were obtained from four men on a pair of Nichols moulding machines. Now 450 boxes were obtained with approximately double the labour.

(In a written contribution after the meeting, Mr. Johnson said he would like to give a little more positive information on two points which had arisen during the discussion. With regard to the question on the saving of manpower by mechanisation, he could state that in his company's light mechanised iron foundry, the output approximated to 1.75 tons per man, while in their small jobbing foundry on small quantity work of a very similar, relatively light, multicored nature, and similar range of weight, the output was about 0.6 tons per man. These figures included all personnel in the two foundries, but did not include the core-making, fettling, inspection, or maintenance personnel.)

Mr. WESTALL also referred to the inlet manifold die casting

which apparently had a very complicated sand core. He asked if Mr. Johnson could give some idea of the saving in time effected by the method which had been employed on that particular job.

Mr. JOHNSON replied that this particular core would be very difficult indeed to make by hand, and a core box of entirely different construction would be needed. While this core had never been made by hand, he believed that it would take something like one and a half to two hours, whereas it was produced in under ten minutes by one man on the core blower. In addition, the blown core was a much better job, being more uniformly rammed.

The greatest savings were made on the more complicated cores, as the saving showed in the time taken to fill the box with sand, and in manning the blower up to the economic limit. Speaking generally, he believed that by blowing, costs were reduced by at least half on the majority of cores, and sometimes—as just indicated—by a good deal more.

Mr. COCKSHUTT said that Mr. Johnson had mentioned the use of two types of mill for the sand preparation, and he would like to know if it was found more difficult to maintain the bond of the sand in the continuous mills than in the batch mills. With regard to the wedge chill test, he asked how this was applied, and what action was taken if the reading obtained was not that desired.

Mr. JOHNSON, answering the first query, said that this was so, because in the continuous mixing mill the sand might be in the mill for only a minute at the most, whereas the milling time could be made any desired time in the batch mixer, but was generally about five minutes. To offset this, a higher addition of bonding agents was required. Where large quantities of sand were needed, the advantages of a continuous plant outweighed this, and as an illustration, about four or five one-ton batch mixers, on a milling time of five minutes, would be required to handle the 50 tons an hour which was obtained from the two continuous mills in his factory.

A wedge chill test was taken every ten minutes from the continuously tapping cupola and from every other tap on the others when on a straight run with one grade of iron. If the chill was higher than desired, an appropriate addition of SMZ alloy was made to reduce the chill to within the desired range. By this means, it was ensured that the metal was right before it was cast. A delayed correction after casting appreciable quantities of iron was unsatisfactory, for then the damage was done. Sometimes if the chill were too soft chromium was added, but this was more exceptional. Many castings were sensitive to chilling in view of the tensile and hardness required, and needed a close metal control.

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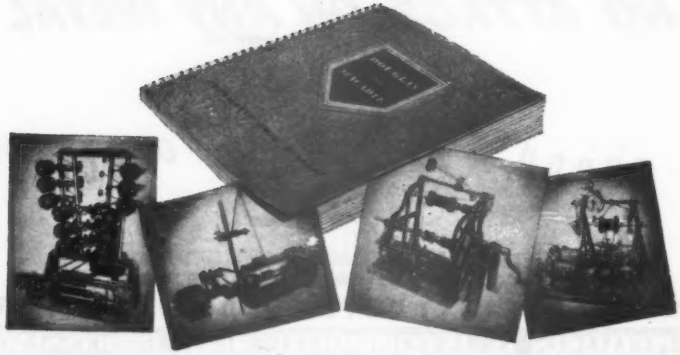

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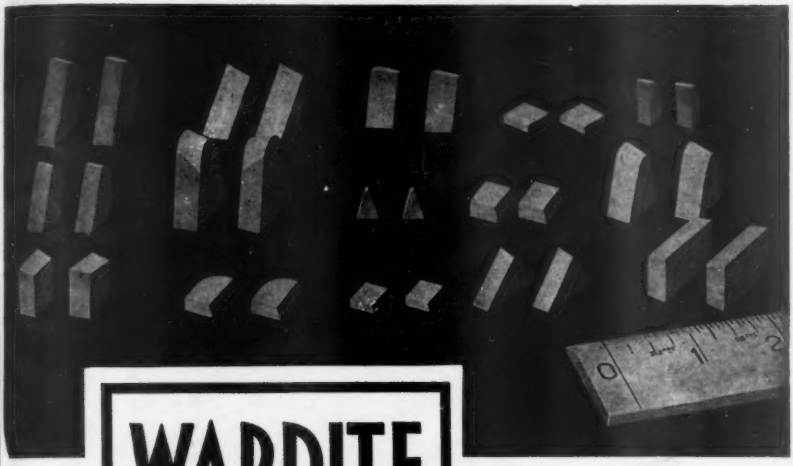

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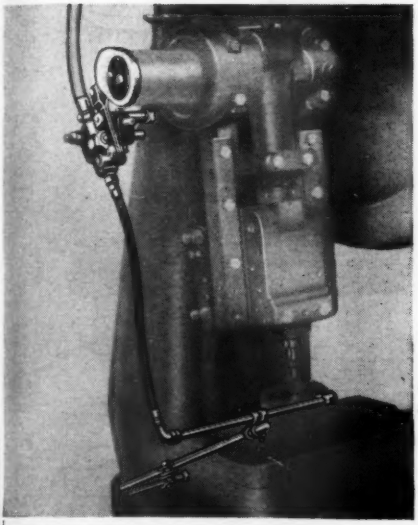

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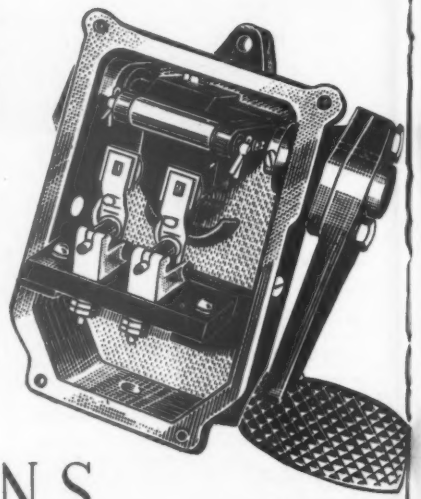

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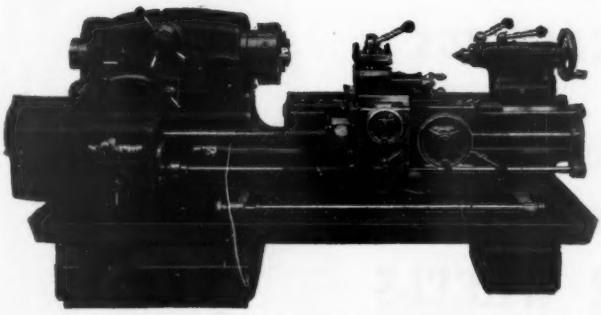

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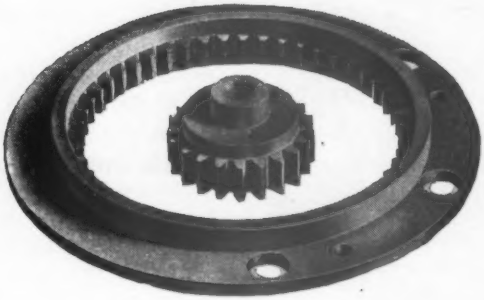

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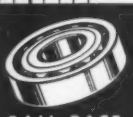

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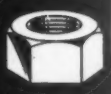

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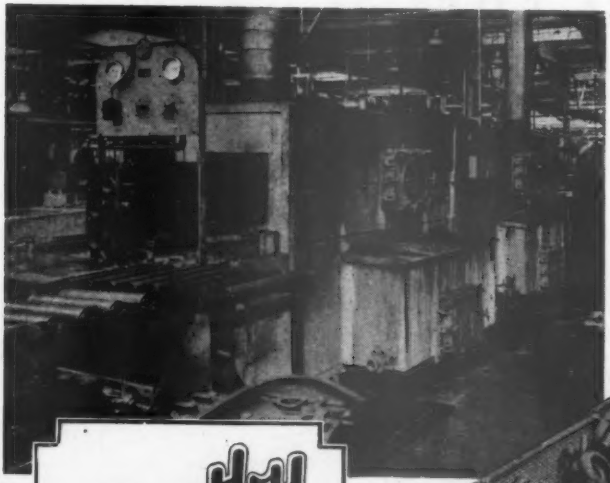

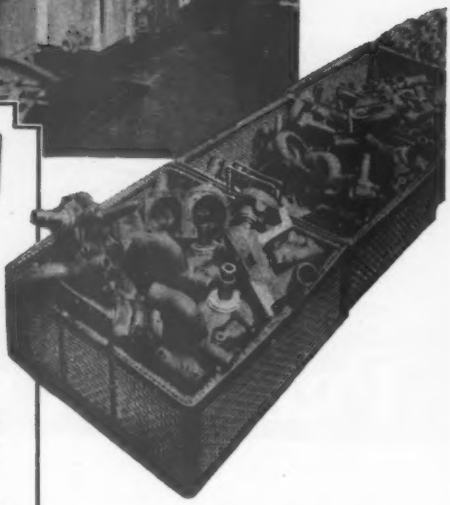

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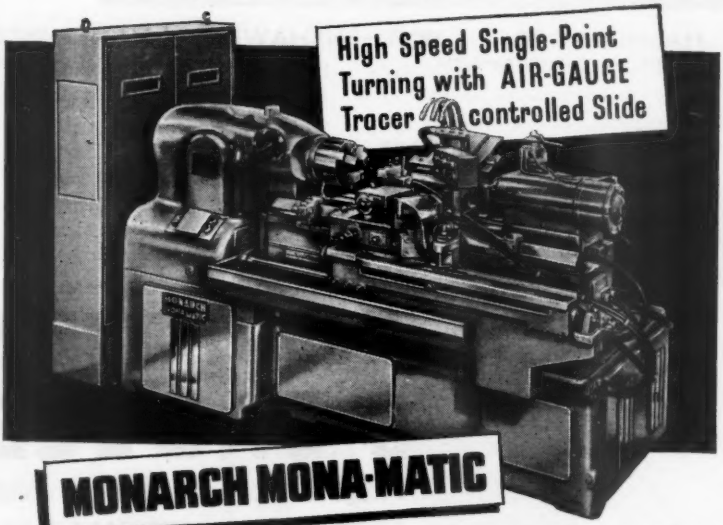

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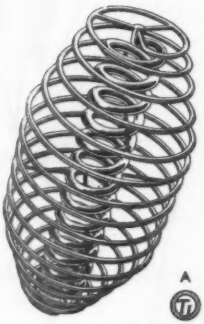

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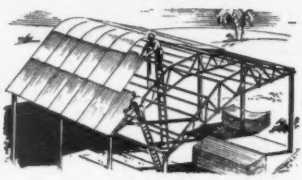

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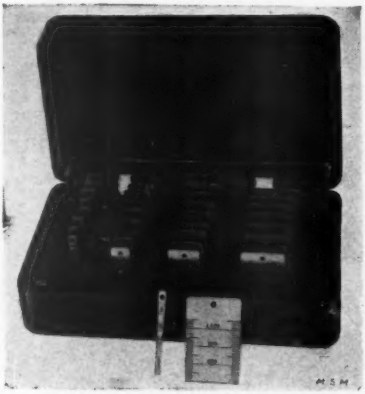

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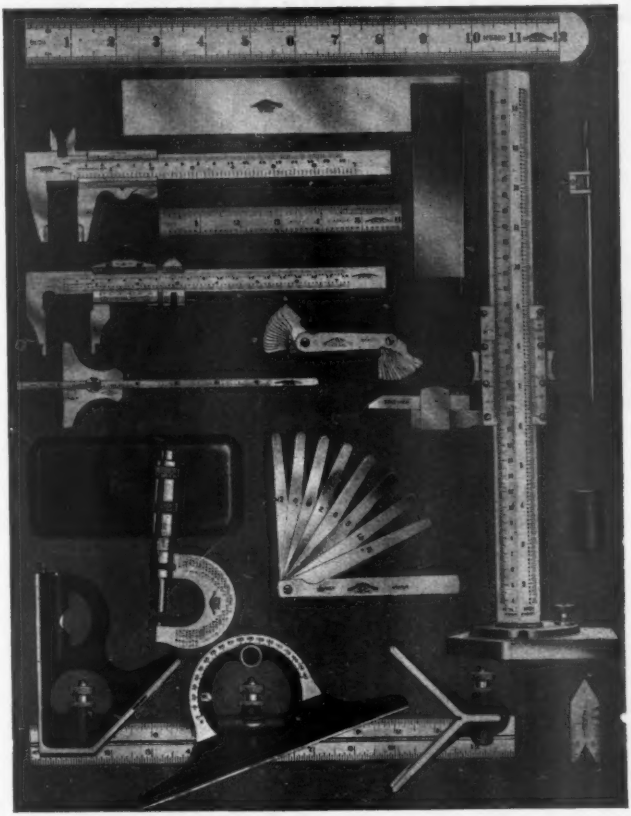

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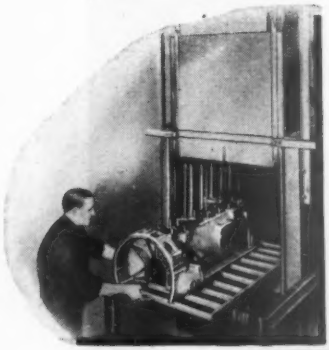

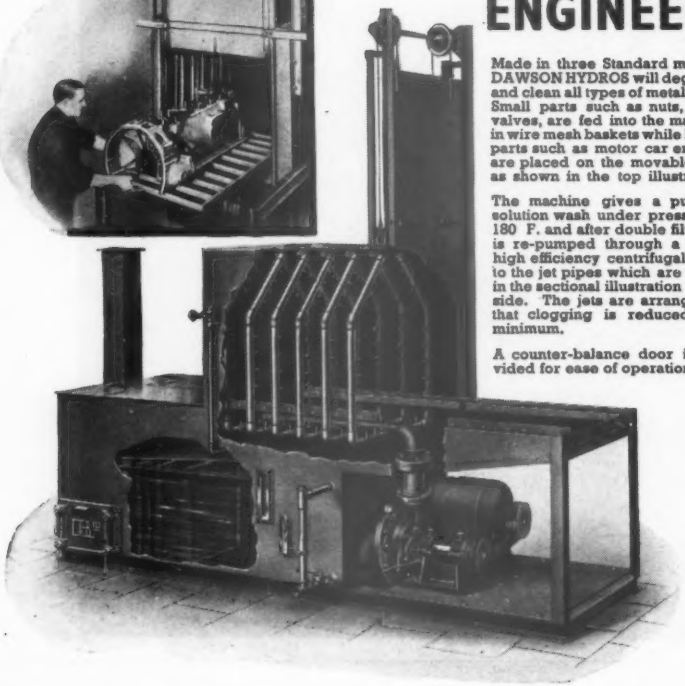

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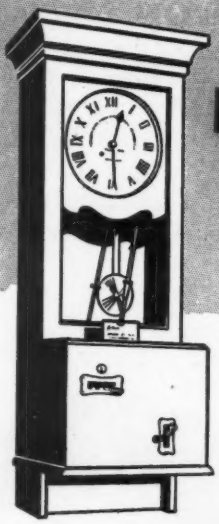

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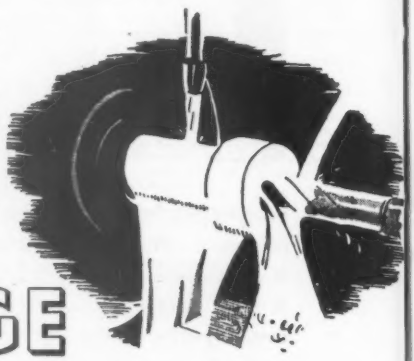

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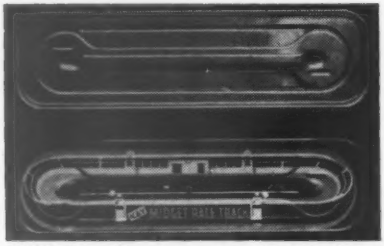

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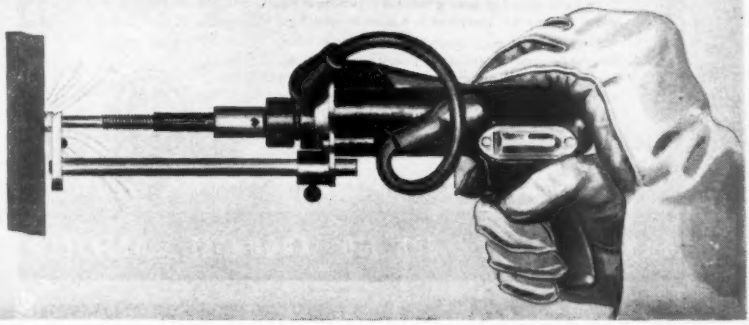

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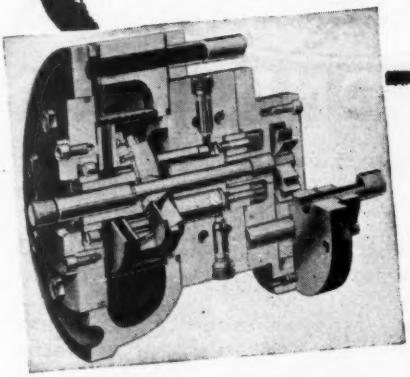

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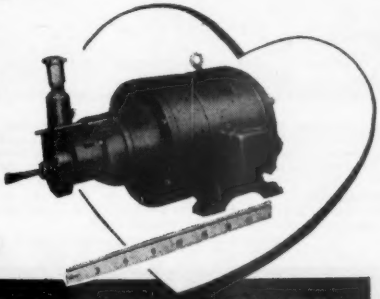

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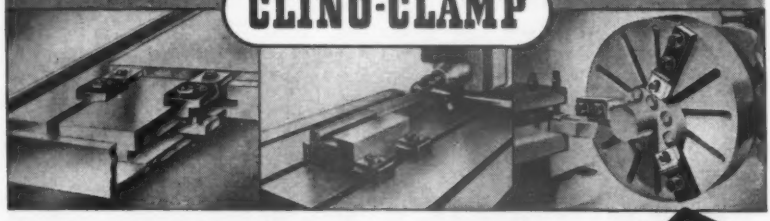

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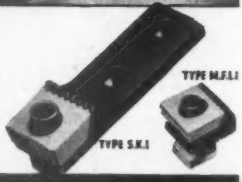

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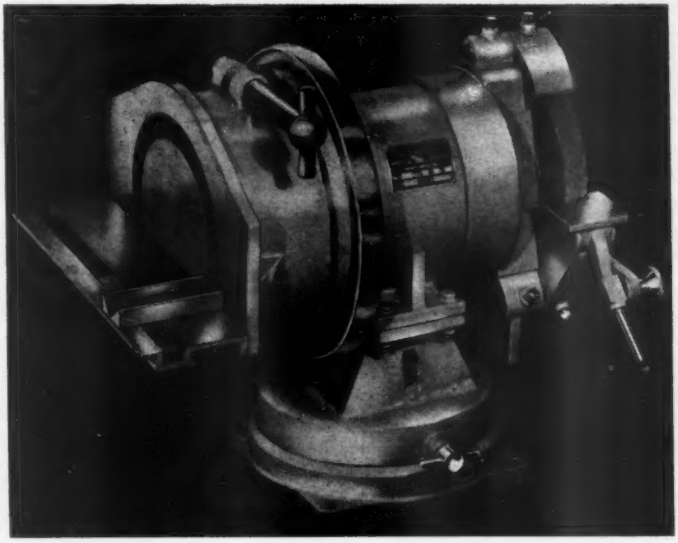

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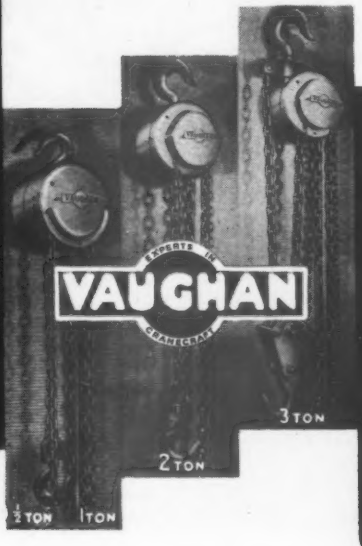

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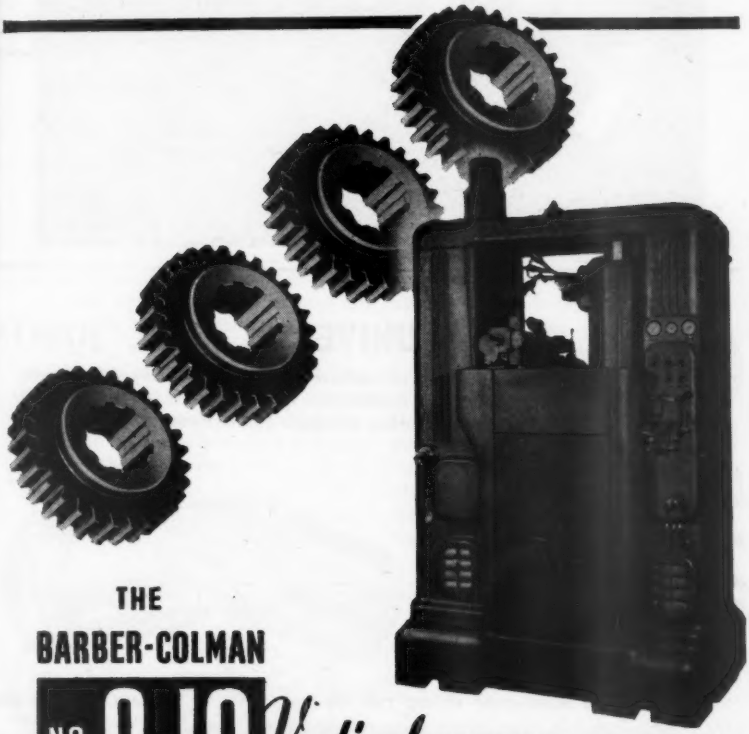

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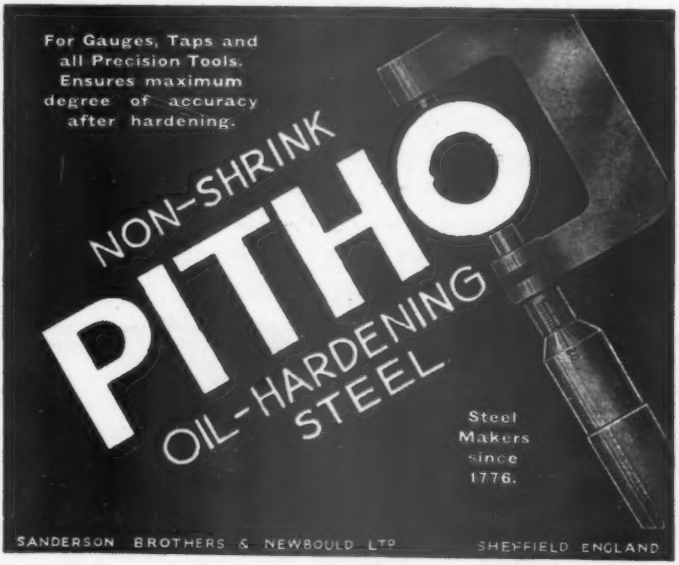
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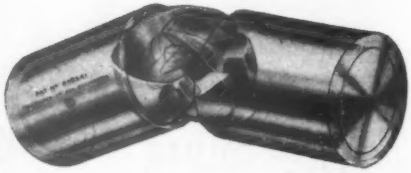

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This is a *one-piece* cast steel bogie frame, one of a number supplied for electric motor coaches recently designed and built by the English Electric Co. Ltd. for the New Zealand Government Railways.

The urgent need for transportation economies and ever-increasing speeds on all railways must involve modernisation of many obsolete types of bogie frames. The cast steel frame bogie is *cast in one piece* and is therefore considered by many Railway Engineers throughout the world to have the necessary strength and rigidity with a much better distribution of metal to meet the varying stresses in different sections than in built-up or fabricated types of bogie frame.

The cast steel bogie frame illustrated is 13′ 4″ *long with journal centres of* 5′ 3″ *for a gauge of* 3′ 6″. *Depth of frame* 1′ 11⅞″ ; *average metal thickness throughout main members* ⅝″ ; *finished weight* 41 *cwts. Permanent true alignment of wheels, motors and other parts is maintained. Efforts of inertia due to heavy buffing and drawbar shocks, and the stresses induced by deceleration when brakes are applied are provided for with an ample margin of safety.*

A Steel Casting is a first-class engineering product

The Secretaries, British Steel Founders' Association, 301 Glossop Road, Sheffield.

BSFA
STEEL CASTINGS

INDEX TO ADVERTISEMENTS

	Page
Abwood Tool & Engineering Co. Ltd.	—
Adam Machine Tool Co., Ltd.	Liii
Ajax Machine Tool Co. Ltd.	—
Arcon, Tropical Products	xxxviii
Automatic Coil Winder and Electrical Equipment Co. Ltd.	xix
Barber & Colman, Ltd.	lx
Benton & Stone, Ltd.	—
Birlec, Ltd.	—
Birmingham Aluminium Casting (1903) Co. Ltd.	—
Bratby & Hinchliffe, Ltd.	xxxiii
British Steel Founders' Association	lxii
Brooke Tool Manufacturing Co. Ltd., The	—
Brooks & Walker Ltd.	—
Broom & Wade Ltd.	lvi
B.S.A., Cycles Ltd.	—
Burton, Griffiths & Co. Ltd.	xiii
Camerer Cuss,	lv
Catmur Machine Tool Corporation, Ltd.	xl
Churchill, Charles & Co., Ltd.	—
Chesterman, James & Co., Ltd.	xlii
Churchill, Machine Tool Co., Ltd. The,	—
Cincinatti Milling Machines, Ltd.	xxxvi
Climax Rock Drill and Engineering Works, Ltd.	xi vii
Collis J. & Sons, Ltd.	*Inside Front Cover*
Coventry Gauge & Tool Co., Ltd.	xvii
Craven Bros. (Manchester) Ltd.	—
Crompton Parkinson, Ltd.	l
Dawson Bros., Ltd.	xliii
Dean, Smith & Grace, Ltd.	xxiv
Deloro Stellite Ltd	xxvi
Donovan Electrical Co., Ltd.	xxiii
Dowding & Doll, Ltd.	—
Drummond Bros., Ltd.	ix
Electro, Dynamic Construction Co., Ltd.	—
English Electric Co. Ltd., The	xv
Equipment Repairs Ltd.	—
Exors. of James Mills, Ltd.	xxxi
Fascol, Ltd.	—
Firth Thos. & John Brown Ltd.	xxvii
Flame Hardeners Ltd.	—
Fletcher Miller Ltd.	xlv
Gill, Samuel & Sons (Engineers) Ltd.	—
Gledhill-Brook Time Recorders Ltd.	xliv
G.P.A. Tools & Gauges, Ltd.	xxxv
Guest, Keen & Nettlefolds, (Midl n s Ltd).	—
Guylee, Frank, & Son, Ltd.	*Inside Back Cover*
Harding, Rhodes & Co., Ltd.	—
Harrison, T. S., & Sons, Ltd.	—
Havelock Engineering, Co., Ltd.	—
High Speed Service Tool Co., Ltd.	xlix
Herbert, Alfred, Ltd.	xxix, xxx
Hilger & Watts, Ltd.	—
Holman Bros. Ltd.	*Back Cover*
Hoover, Ltd.	liv
Hordern, Mason & Edwards, Ltd.	—
Hoyt Metal Co. of Great Britain Ltd.	xlix
Imperial Smelting Corporation, (Sal s) Ltd.	xlviii
Johansson, C. E., Ltd.	—
King, Geo. W., Ltd.	—
Lancashire Dynamo & Crypto, Ltd.	—
Lang, John, & Sons, Ltd.	—
Lloyd, Richard, Ltd.	xxi
Lund, John, Ltd.	xxxii
Marco Conveyor & Engineering Co., Ltd.	—
Marton Air Equipment	—
Mercer, Thos., Ltd.	—
Mills, John & Co., (Llanidloes) Ltd.	—
Mollart Engineering Co., Ltd.	lxi
Monks & Crane, Ltd.	xvi
Morgan, George, Ltd.	—
Motor Gear & Engineering Co., Ltd.	—
McKechnie Bros. Ltd.	—
Newall, A. P., & Co., Ltd.	iii
Newall Group Sales Ltd.	xxxix
Norton Grinding Wheel Co., Ltd.	xiv
Osborn, Samuel & Co., Ltd.	xii
Parkinson, J., & Son (Shipley) Ltd.	v
Parsons Chain Co. Ltd.	—
Pitman, Sir Isaac & Sons Ltd.	lvii
Power Jacks Ltd.	—
Procter Bros., (Wireworks) Ltd.	lv
Protolite, Ltd.	xxviii
Pryor, Edward, & Son, Ltd.	li
Pultra, Ltd.	—
Ransomes Sims & Jefferies Ltd.	—
Reavell & Co., Ltd.	xli
Rockwell Machine Tool Co., Ltd.	xxxiv
Sanderson Bros. & Newbould, Ltd.	lxi
Schrader's, (A) Son	xxii
Scrivener, Arthur, Ltd.	—
Sheffield Twist Drill & Steel Co. Ltd., The	xlvi
Sparklets Ltd.	lix
Spencer & Halstead Ltd.	—
Steel Band Conveyor & Eng., Co., Ltd.	—
Sterling Metals Ltd.	—
Sunbeam Anti-Corrosives, Ltd.	xviii
Swift, Geo., & Son, Ltd.	—
Sykes, W. E. Ltd.	vi
Talbot-Stead Tube Co. Ltd.	xxxvii
Taylor & Jones, Ltd.	li
Technically Controlled Castings Group, The	liii
Towler Bros. (Patents) Ltd.	lii
Tyne Truck & Trolley Co. Ltd.	—
Unbrako Socket Screw Co., Ltd.	vii
Universal Tools, Ltd.	lvii
Van Moppes & Sons (Diamond Tools) Ltd.	—
Vaughan, Edgar, & Co. Ltd.	—
Vaughan, Crane Co. Ltd.	lix
Vickers-Armstrongs Ltd.	—
Ward, H. W., & Co., Ltd.	iv
Ward, Thos., W., Ltd.	xx
Wickman, A. C., Ltd.	x, xi
Williams & James (Engineers) Ltd.	—
Wild Barfield Electric Furnaces Ltd.	—
Wolverhampton Die Casting Co., Ltd.	xxv
Young, John S. & Co., Ltd.	lviii
Zinc Alloy Die Casters Association	viii

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"ARCHER" AUTO-REVERSE FRICTION DRIVE TAPPING ATTACHMENT

THE IMPROVED "ARCHER" tapping attachment is a PRECISION TOOL, all components subject to considerable wear are of finest steel, hardened and ground. The design and workmanship make the "ARCHER" tapper mechanically superior to all others. It does more and better work, and lasts longer.

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SPECIAL FEATURES. Suitable for tapping either Open or Blind Holes. Will work in Horizontal or Vertical position. Standard Fitter's hand Taps are used.

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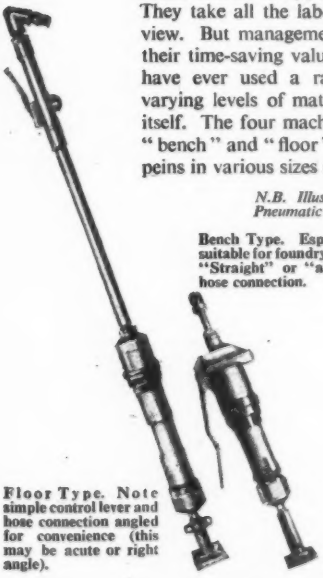

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H.A.7

TYPE	SIZE	L'TH ins.	WT. lb.
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BENCH	10	23	18
FLOOR	20	48	22
FLOOR	30	47	27

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